

ACIDIC PRECIPITATION IN ONTARIO STUDY

STUDIES OF LAKES AND STREAMS PUKASKWA NATIONAL PARK

APIOS REPORT 003/83

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ACIDIC PRECIPITATION IN ONTARIO STUDY

STUDIES OF LAKES AND STREAMS
PUKASKWA NATIONAL PARK

APIOS REPORT 003/83

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FOREWORD

This report has been prepared by Lakehead University for the Ontario Ministry of the Environment, Northwestern Region. Under the terms of a contract with the Ministry, Lakehead University is conducting the terrestrial and aquatic components of a regional Acid Precipitation in Ontario Study (APIOS). This document reports the findings of the aquatic effects program in Pukaskwa National Park.

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SUMMARY

Pukaskwa National Park is located in an area of the North-western Ontario Precambrian Shield which is highly sensitive to acidic deposition. Acidic and acid-stressed lakes have been identified in the park, where the wet deposition of sulphates is estimated at approximately $1.5 \text{ g/m}^2/\text{yr}$. The pH of precipitation in this area has decreased approximately one unit to 4.6 in the last 25 years. With the exception of the park lakes, Ontario Ministry of the Environment sampling of approximately 420 lakes in Northwestern Ontario had not revealed any acidic lakes (alkalinity $< 0 \text{ mgL}^{-1}$). Of 39 lakes surveyed in the park in 1981-82, three acidic lakes and 10 extremely sensitive lakes were found. Depressions of pH and total inflection point alkalinity in park lakes, and to a greater extent in streams, were observed to coincide with major rainfall events. Conversely, marked increases in pH and alkalinity were observed during periods of low precipitation. Sulphate deposition rates in the park are lower than other areas in the world where acidification is a major concern, but sulphate concentrations in the park lakes were higher than in other Northwestern Ontario lakes studied. Park lakes near Lake Superior receive more precipitation and higher acid loadings than lakes inland, and have significantly higher sulphate concentrations. A number of lakes are highly coloured. Colour has previously confused the interpretation of acidification in these lakes. When colour is taken into account in two empirical relationships, however, it is clear that the park lakes have been affected significantly more by acidic deposition than a set of lakes of similar colour in the Atikokan area. In addition, pH levels were lower and concentrations of aluminum were much higher in the park lakes than in Atikokan lakes of similar colour.

INTRODUCTION

Pukaskwa National Park is located at approximately $48^{\circ} 15'$ latitude and $86^{\circ} 00'$ longitude, on the northeastern shore of Lake Superior (Figure 1). The park encompasses about 1,840 square kilometres of some of the highest and most rugged terrain in Ontario. Many outcrops of early Precambrian felsic, igneous, and metamorphic bedrock occur, while thin glacial till and predominantly acidic soils make up the surficial deposits (Duff, et al., 1983, in prep.). Mean annual precipitation and snowfall measurements are approximately 85 and 285 cm respectively (Chapman and Thomas, 1968). Gimbarzevsky et al. (1978), however, report higher precipitation near Lake Superior than further inland, owing to a "maritime effect". Interpolated 1981 precipitation data indicate that precipitation pH in the park is approximately 4.5, and that wet sulphate, nitrate, and free hydrogen ion loadings are approximately 1.5, 0.225, and 0.025 g/m²/yr. (Chan, Tang, and Lysis, 1983). A much higher sulphate loading (2.217 g/m²/yr.) was reported for the Algoma area, approximately 200 km southeast of the park (Bangay and Riordan, 1983) which may be due to the greater annual precipitation (102 cm) in this area (Chapman and Thomas, 1968). Precipitation pH in the park area has apparently experienced a decrease of approximately one pH unit in the 25-year period from 1955-56 to 1980-81 (Figure 2).

The first aquatic surveys of lakes and streams in Pukaskwa National Park were conducted by Ward (1972, 1974, 1975a, 1975b). Water chemistry was included in these studies, however, sampling was limited and the interpretation of results was directed towards lake fertility and fisheries potential. In the fall of 1981, staff of the Ontario Ministry of the Environment and Pukaskwa National Park began a joint water quality surveillance program designed specifically to evaluate the sensitivity of park waters to acidic deposition. Preliminary results indicated that a high proportion of the lakes were extremely to moderately sensitive to acidic deposition. Because these lakes were the most sensitive found in Northwestern Ontario, a program to identify and describe

conditions was formulated for 1982-83. The objectives for the 1982-83 program included monitoring the water chemistry of 20 lakes and three stream mouths. Also scheduled were the surveillance of 10 additional lakes and biological surveys of five small headwater lakes.

This report summarizes and includes interpretation of 1981-82 water chemistry data from Pukaskwa National Park lakes and streams. Problems with measuring the degree of acidification in coloured waters are addressed. Many study lakes in Pukaskwa National Park had sparse fish populations or no fish. A detailed evaluation of the relationship between acidic deposition and fish communities is not included in this report. Results of the biological surveys will be reported separately.

METHODS

A float-equipped helicopter was used to visit the lakes. In 1982, mid-lake composite water samples were obtained by lowering an acrylic sampler containing two one-litre glass bottles to a depth of either one metre above the bottom, or to a depth of 12 metres, whichever was the lesser depth. Samples were preserved and transported to the Ontario Ministry of the Environment laboratory in Thunder Bay for analysis. Low level sulphate determinations were performed at the Ministry laboratory in Toronto. Methods for the analysis of all parameters are given in the publication "Outlines of Analytical Methods" (Ontario Ministry of the Environment, 1981a).

RESULTS

Selected physical characteristics of all 39 lakes and six streams surveyed in 1981 and 1982 are presented in Table 1. Many lakes were located at greater than 335 metres above sea level.

Additionally, 21 lakes have watershed: lake-area ratios of 12:1 or less. Only 12 lakes had colour measurements of less than 20 Hazen Units; 81 Hazen Units was the maximum recorded.

Lake and stream chemistry data are tabulated in Appendices A and B. Each appendix lists the results of 12 parameters. Three acidic lakes, ten extremely sensitive lakes (0.1 - 2.0 mg/l alkalinity), and eighteen moderately sensitive lakes (2.1 to 10 mg/l alkalinity) were found in the park. The lowest pH recorded was 4.75, while pH measurements for an additional four lakes were less than 5.5.

Following major rainfall events recorded at Wawa, decreases in alkalinity, pH and conductivity occurred in a number of park lakes but were more apparent in streams. Conversely, increases of these parameters followed periods of low precipitation. The lowest stream pH measured was 5.8 in Nichols Cove Creek, and the greatest difference in pH between two sampling occasions was 1.5 units (7.7 to 6.2) on the White Gravel River.

Sulphate concentrations in the park lakes ranged from 3.8 to 7.5 mg/l, with a mean and standard deviation of 5.2 and 0.87, respectively. The acidic lakes are located 15 km or less from Lake Superior. Sulphate concentrations in these lakes are significantly higher ($P < 0.01$) than in lakes studied further inland. On an equivalent basis, sulphate concentrations exceeded bicarbonate concentrations in 24 of the 39 lakes (Table 2). It is also evident (Table 2) that the sum of the cations (Σ^+) almost always exceeds the sum of the anions (Σ^-). This difference averaged 27 $\mu\text{eq/l}$ in 1982 data.

Sixteen of 28 lakes sampled for metals had mean total aluminum concentrations exceeding 0.1 mg/l, the Provincial guideline for the protection of aquatic life (Ontario Ministry of the Environment, 1978) and four exceeded 0.3 mg/l total aluminum (Appendix B). Table 3 compares metal concentrations of lakes in Pukaskwa National Park, Northwestern Ontario, Sudbury, Norway and Sweden. The mean aluminum concentration in the park lakes is

well above mean concentrations for Northwestern Ontario and the Sudbury area. Also, concentrations of other metals in the park lakes are generally greater than "background" concentrations in Northwestern Ontario lakes, but are not as high as concentrations in the Sudbury lakes.

A correlation coefficient matrix of major water quality parameters is illustrated in Table 4. Most notable are the relationships between pH and the metals aluminum, manganese, and zinc ($r = -0.81$, -0.69 and -0.80 , respectively), and between colour and aluminum ($r = 0.79$).

Of the six lakes, which are either extremely sensitive or acidified, only Perry Lake has a fish community with more than one species. The other lakes are either devoid of fish, or are inhabited only by the brook stickleback (Culaea inconstans) Ward (1972).

DISCUSSION

Pukaskwa National Park lakes in this study exhibit a wide variety of physical characteristics (Table 1), but the lakes are generally unproductive. Measurements of total phosphorus were between 3 and 12 $\mu\text{g}/\text{l}$. Many of the park lakes exhibit dystrophy because they are low in productivity and are highly coloured; however, they are not dystrophic bog lakes. It is presumed that the park lakes are coloured as a result of humic and fulvic acids and humic colloids as described by Wetzel (1975). Because such compounds contribute to the natural depression of pH in surface waters (Bangay and Riordan, 1983), where possible, colour is taken into account in the following discussions.

The three acidic lakes, MOE 01, LU 05 and LU 08, are small headwater lakes, located within 9 km of each other. All three are within 8 km of Lake Superior. These lakes are located within the "maritime effect" zone adjacent to Lake Superior. The four alkalinity measurements for lake MOE 01 in Appendix A suggest that acidification of the lake is a recent phenomenon.

Except for the three acidic lakes in Pukaskwa National Park, surveillance of approximately 420 lakes in Northwestern Ontario from 1979 to early 1983 did not reveal any acidified water bodies (Sutton *et al.*, 1983, in prep.). Although acidified lakes have been reported near Wawa and Sudbury (Ontario Ministry of the Environment, 1981b), those lakes have been impacted by atmospheric emissions from localized ore processing industries. In both the Wawa and Sudbury areas, most affected lakes were found northeast and southwest of the point sources, coincident with the prevailing wind surface patterns (Somers, 1980; Ontario Ministry of the Environment, 1982).

Potential point sources of acidic deposition in the park include a pulp and paper complex at Marathon, and an iron sintering plant at Wawa. The pulp and paper complex at Marathon is located approximately 60 km northwest of the acidic lakes, and emits 4,900 tons of SO_x into the atmosphere per year (MOE, unpublished data). Wind data for Marathon are not available. The iron sintering plant at Wawa is located approximately 100 km east-southeast of the acidic lakes, and emits 225,000 tons of SO_2 into the atmosphere per year (Somers, 1980). Wind data for Wawa (Environment Canada) indicate that winds from the southeastern quadrant occur only 13.2 percent of the time. Emissions from both point sources probably contribute to the total acidic deposition in the park. Given the prevailing winds, however, the relative contributions from the point sources are probably of little importance in comparison to long-range transport.

The depressions of pH and alkalinity in lakes (Appendix A) and streams (Figures 3a and 3b) following major rainfall events are probably the net result of several factors. These include low precipitation pH, mobilization of dry acidic deposition, steep basin morphometry, and thin, carbonate-poor soils. Stream water chemistry is related to rainfall; however, the sampling frequency was such that the extent and duration of pH, alkalinity and conductivity fluctuations are not defined. Fluctuations in pH, alkalinity and conductivity were also observed in 21 streams flowing into Lake Superior, between Sault Ste. Marie and Wawa

(Keller and Gale, 1982). Here, the minimum pH recorded and the lowest concentrations of most major ions were observed during spring runoff. Similarly, the values of pH, alkalinity and conductivity in the park streams were generally at a minimum in the spring; however, some values were lower in July. This indicates that the full effect of the spring melt may not have been detected by the sampling frequency used.

The atmospheric deposition of sulphates (SO_4) has been associated with the occurrence of acid-impacted lakes (Wright et al., 1980; Henriksen, 1979; Dickson, 1978; Harvey et al., 1981). At approximately $1.5 \text{ g/m}^2/\text{yr.}$, the wet deposition of SO_4 in the Pukaskwa National Park area is low, compared to deposition rates of 3.5-8.6, 2.9-6.2 and 2.9-5.8 $\text{g/m}^2/\text{yr.}$ in southeastern Canada, northeastern U. S. A. and southern Scandinavia, respectively (Harvey et al., 1981). The SO_4 deposition rates for the Park are, however, somewhat higher than the deposition rates in the Atikokan area ($48^\circ 15'$ lat., $91^\circ 35'$ long.), which are approximately $1 \text{ g/m}^2/\text{yr.}$ (M. Lusi, 1983, personal communication).

Elevated concentrations of SO_4 in lakes have been associated with increased deposition rates of strong acids (Harvey et al., 1981; Wright et al., 1980). The maximum background SO_4 concentration for Canadian Shield lakes has been suggested by Harvey et al., 1981, to be about 2.0 mg/l. As illustrated in Table 5, SO_4 concentrations in Northwestern Ontario lakes are somewhat higher than background, and are highest in Pukaskwa National Park lakes.

The higher SO_4 concentrations in the Pukaskwa National Park lakes may also be related to the high colour values. Dystrophic lakes in the Experimental Lakes Area (50 km southeast of Kenora, Ontario) are reported to have high SO_4 concentrations (Harvey et al., 1981). Colour and SO_4 were not significantly correlated in either Atikokan or Pukaskwa Park lakes but Table 5 shows that, for similarly coloured lakes, SO_4 concentrations increase from west to east. For Northwestern Ontario, similar west to east increases in SO_4 concentrations have been reported by Bangay and

Riordan (1983). These SO_4 concentrations are a result of the increasing gradient of SO_4 deposition from west to east (Bangay and Riordan, 1983, and Harvey *et al.*, 1981). As expected, the Pukaskwa National Park lakes have higher sulphate concentrations than lakes in other parts of Northwestern Ontario. The data, although limited, indicate that sulphate concentrations in the acidified lakes are not significantly higher than nearby non-acidified lakes in the park. Lakes which are less than 15 km from Lake Superior, however, have significantly higher SO_4 concentrations than lakes further inland.

A consistent characteristic of acidified waters is the replacement of bicarbonate by sulphate (Henriksen, 1980). In areas west of Pukaskwa National Park, preliminary data indicate that bicarbonate concentrations are exceeded by sulphate only in a small proportion of lakes; which are extremely sensitive (Sutton *et al.*, 1983; in prep.). In contrast, sulphate exceeds bicarbonate for at least half of the park lakes (Table 2).

Table 2 shows that the sum of measured cations (Σ^+) is almost always greater than the sum of the measured anions (Σ^-). Except where noted, the mean cation and anion concentrations in Table 2 are 1982 data (see also Appendix A). Prior to 1982, detection limits for calcium and magnesium were 2 and 1 mg/l; inadequate for establishing a mass balance for dilute systems. The 1982 data, however, show a difference between the cations and anions averaging 27 $\mu\text{eq/l}$. The cause of this deviation is probably associated with the measurement of, or lack of measurement of some charged particles in solution, possibly fluorides. Testing showed, however, that fluoride concentrations were below the detection limit (5.3 $\mu\text{eq/L}$). Another possibility is the overestimation of calcium and magnesium in coloured waters. Coloured waters contain organically-bound (non-ionic) calcium and magnesium. Since total cations are measured, the reported value is likely greater than the actual concentration of reactive ions in solution (Henriksen, 1980). The presence of organic anions may also be significant. Bangay and Riordan (1983) suggest that

the organic anion concentration in coloured waters can be estimated using the ion balance approach. In fact, colour may be a surrogate measure for organic anions in solution (B. Neary, 1983, personal communication). The presence of organic materials in lake waters provides a plausible explanation for the apparent ionic imbalance noted. This is supported by a strong relationship ($r = 0.90$) between the ratio of Σ^+/Σ^- and colour (Figure 4).

In those areas of Scandanavia and North America relatively unaffected by acidic deposition, Almer (1978) and Henriksen (1980) determined that lakes exhibited approximately a 1:1 relationship between the alkalinity and the sum of calcium and magnesium. They also noted that calcium and magnesium concentrations increased and/or bicarbonate concentrations decreased in lakes from "polluted" areas; presumably from the deposition of acidic materials. Figures 5a and 5b illustrate least-squares regression lines mean alkalinity as a function of the sum of calcium and magnesium for Pukaskwa National Park and Atikokan area lakes. These figures illustrate data for lakes with mean colour measurements greater than 30 Hazen Units and less than 30 Hazen Units, respectively. In both figures, all regression lines are "shifted" to the right of the 1:1 line. Comparing the two figures, the highly coloured lakes are shifted slightly more than the less coloured lakes, and the park lakes are shifted the furthest. The mean colour of the Atikokan small lake set is higher than for the other groups by a factor of two or more (Table 6). If colour played a significant role in the deviation of the regression line, the greatest deviation would be seen for the Atikokan small lake set. This is not the case; the greatest shift is seen for the park lakes. Furthermore, it appears that colour does not greatly influence the magnitude of the line shift for the park lakes. The two lake sets in the park, exhibiting widely different mean colour values, are affected similarly.

Henriksen (1979) also separated acid-affected and unaffected lakes by plotting pH as a function of calcium concentration. Lakes located above the line are acid-affected and those located

below the line are not affected. Henriksen cautioned, however, that the indicator line might imply apparent acidification where none had occurred if applied to waters containing high concentrations of natural organic acids.

Figures 6a and 6b, illustrate Henriksen's empirical line, as well as 1982 data from the park and preliminary data from the Atikokan area. These figures further indicate that colour does not account significantly for the acidification of park lakes.

Figure 7 illustrates least-squares regression lines of pH as a function of colour for the park lakes and Atikokan area lakes. As would be expected, pH generally declines with increasing colour, however, the pH of the park lakes decreases much more rapidly with increasing colour than the Atikokan lakes. The pH-colour relationship for the Atikokan lakes is considered near-background. If the organic materials represented by colour in both the Atikokan and park lakes contribute the same number of hydrogen ions (H^+) per unit colour, then the park lakes have a lower pH than would be expected. The probable cause is the greater sulphate loading on the park compared to the Atikokan area.

As a result of the atmospheric deposition, elevated concentrations of metals have been found in lakes and streams in Scandinavia and North America (Harvey *et al.*, 1981). In most lakes and streams in close proximity to pollutant sources, elevated concentrations of cadmium (Cd), copper (Cu), lead (Pb) and nickel (Ni) are frequently caused by direct metals deposition. Elevated concentrations of aluminum (Al), manganese (Mn) and zinc (Zn) may also occur, but are a result of the increased metal solubility within the watershed. Acidic deposition can take place with or without atmospheric metals deposition (Bangay and Riordan, 1983). In the Pukaskwa Park lakes, concentrations of Al, Mn and Zn are above Northwestern Ontario background concentrations as represented by the mean values for 57 lakes in Northwestern Ontario (Table 3). Concentrations of Cd, Cu, Pb and Ni, however, are near background.

In the park lakes, aluminum appears to be more affected by colour and low pH than other metals tested. Table 4 indicates that aluminum is highly correlated with colour ($r = 0.79$). Correlation coefficients for manganese, iron, copper, zinc and cadmium with colour are all less than 0.50. Aluminum concentrations in Atikokan area lakes ($n = 70$) are similarly correlated with colour ($r = 0.93$), however, least-squares regression lines of mean Al as a function of colour for both Atikokan and the park lakes (Figure 8) indicate that for a given colour, the park lakes have much higher Al concentrations.

The foregoing discussion indicates that although colour complicates the phenomenon of lake acidification, it alone does not account for the acidified status of three lakes in Pukaskwa National Park.

CONCLUSIONS

1. The acidification of three lakes in Pukaskwa National Park appears to have occurred recently. Aluminum concentrations in these lakes are very high.
2. Many lakes in Pukaskwa National Park are among the most sensitive to acid deposition in Ontario.
3. Colour is recognized as being associated with low pH in natural waters. Colour alone, however, does not account for the negative alkalinities observed in three park lakes.
4. It is not likely that local sources of SO_2 emissions at Marathon and Wawa contribute significantly to acid loadings in the study area.
5. Relatively low levels of wet sulphate deposition ($1.5 \text{ g/m}^2/\text{yr.}$) appear sufficient to affect sensitive aquatic systems.
6. Additional detailed study is required to adequately quantify the rates of change of water quality in lakes and streams in Pukaskwa National Park.

ACKNOWLEDGEMENTS

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TABLE 1. Selected characteristics of Pukaskwa National Park lakes and streams. Unnamed lakes are abbreviated to U.L.

Lake/Stream	Location (UTM Coordinates)	Elevation (Metres Above Sea Level)	Lake Surface Area (Hectares)	Watershed Area (Hectares)	Watershed: Lake Ratio	Maximum Measured Depth (Metres)	Secchi Disc (Metres)	Colour (Hazen Units)
Buchanan	741 255	235	34.5	113	3.3	>30	4.5-6.5	7-12
Caribou	583 682	250	16.0	177	11.1	-	-	54
Cascade	812 335	340	44	389	8.8	>30	1.5-3	31-81
Gornupkagama	990 524	435	78.8	2350	29.8	>30	2.5-3	41-45
Lost	642 435	190	5.0	54	11	9	-	26
Lurch	862 667	355	152	15100	99.3	-	-	24
Mountain	673 384	235	17.2	96	5.6	17	3-7	14-23
Perry	905 264	310	40.8	1320	32.3	28	1.5-3.5	32-66
South Soldier	907 603	370	46.2	218	4.7	-	-	7
U.L. LU 01	912 487	450	29.5	283	9.6	14	3.5-5.5	16-23
U.L. LU 02	701 589	370	30.0	434	14.5	14	2.5-3	30-35
U.L. LU 03	725 585	295	9.0	161	18	4.5	2.5-3	30-36
U.L. LU 04	617 546	295	14.0	162	11.6	8	2.5	45-52
U.L. LU 05	704 482	435	18.0	998	55.4	>30	1.5	67-73
U.L. LU 06	678 544	325	5.2	158	30	12	2.75	53-61
U.L. LU 07	653 557	295	9.2	241	26	18	3	36-37
U.L. LU 08	700 449	370	18.2	2320	127	9	-	79

TABLE 1. (Continued).

Lake/Stream	Location (UTM Coordinates)	Elevation (Metres Above Sea Level)	Lake Surface Area (Hectares)	Watershed Area (Hectares)	Watershed: Lake Ratio	Maximum Measured Depth (Metres)	Secchi Disc (Metres)	Colour (Hazen Units)
U.L. 6A27	637 568	340	3.5	18	5.1	16	6-7	6-8
U.L. 6D14	898 650	400	29.2	224	7.7	12	2-5.5	12-25
Widgeon	060 463	400	149	444	3.0	-	-	8
Willow	731 681	325	26	3750	144	-	-	29
Cascade R.	709 313*			28234				
Nichols Cove Ck.	599 581*			417				
North Swallow R.	662 402*			5263				
Oiseau Ck.	597 607*			3180				
Swallow R.	682 359*			14295				
White Gravel R.	623 503*			10689				

*Location of stream mouth of Lake Superior.

TABLE 1. (Continued).

Lake/Stream	Location (UTM Coordinates)	Elevation (Metres Above Sea Level)	Lake Surface Area (Hectares)	Watershed Area (Hectares)	Watershed: Lake Ratio	Maximum Measured Depth (Metres)	Secchi Disc (Metres)	Colour (Hazen Units)
U.L. LU 09	694 422	335	35	3630	100	6	-	55
U.L. MOE 01	675 490	435	12.5	101	8.1	10	2.5-4	20-42
U.L. MOE 02	682 472	420	9.2	105	11	18	4-6	22-29
U.L. MOE 03	810 500	540	21.5	379	17.6	19	1.5-3.5	59-75
U.L. MOE 04	872 512	450	24.8	281	11.3	2.5	>2.5	14
U.L. MOE 05	828 310	340	12.5	82	6.6	>15	4	37
U.L. MOE 06 (Secret)	088 395	510	20.5	96	4.7	8	2.5-4.5	33-36
U.L. MOE 07	097 407	465	27.5	268	9.8	14	3.5	37-39
U.L. MOE 08	720 675	295	10.0	186	18.6	7	6	22
U.L. MOE 09	673 605	385	16.0	145	9.1	17	4-7.5	14
U.L. MOE 10	656 415	220	11.5	92	8.0	17	3-6.5	18-26
U.L. MOE 11	781 271	295	5.2	44	8.5	5	3.5	23
U.L. MOE 12	942 403	402	15	106	7.1	23	2.75-3.5	40-45
U.L. MOE 16	815 573	495	7.5	92	12.3	16	3-5	49-58
U.L. MOE 17	885 403	420	34.5	860	24.9	13.5	3-5.5	27-29
U.L. 6A22	630 577	310	11.5	180	15.6	>15	3-6.5	21-26
U.L. 6A24	625 570	325	6.8	116	17	5	2.5-3	17-24
U.L. 6A25	631 572	325	6.5	44	6.8	>15	3-5	13-29

TABLE 2. Mean cation and anion concentrations ($\mu\text{eq}/\ell$), Pukaskwa National Park lakes, 1981-1982. Lakes marked with an asterisk (*) were only sampled in 1981, otherwise 1982 data from Appendix A used exclusively (see text). Lakes are listed in order of lowest to highest bicarbonate (alkalinity) concentrations, unnamed lakes are abbreviated U.L.

Lake	CATIONS							ANIONS				
	Ca^{++}	Mg^{++}	Na^+	K^+	H^+	NH_4^+	Σ^+	SO_4^{--}	HCO_3^-	Cl^-	NO_3^-	Σ^-
U.L. LU 08	65	23	7.0	5.1	17.6	0.6	118	81	-18.8	5.6	0.3	87
U.L. LU 05	65	22	9.1	8.6	12.5	2.5	120	86	-12.8	7.1	0.8	94
U.L. MOE 01	65	22	15	13.2	9.3	1.1	116	108	-6.5	6.6	0.6	115
U.L. MOE 03	82	30	13	1.8	3.9	1.7	132	85	8.8	4.7	1.3	100
U.L. MOE 16	78	28	15	2.4	3.1	2.4	129	87	13.3	4.7	0.8	106
U.L. 6A24	83	30	25	5.5	1.2	1.1	146	112	13.7	8.5	0.3	135
U.L. MOE 02	98	27	18.3	5.1	2.0	3.1	154	115	18.1	8.5	1.3	143
U.L. 6D14	80	22	12	1.0	0.9	1.9	118	84	20.9	4.7	0.8	110
Perry	111	41	16	6.0	1.9	0.9	177	108	25	8.5	2.1	143
U.L. LU 09	115	37	21	6.7	0.9	0.6	181	112	30.0	8.5	0.3	151
U.L. 6A27	95	31	24	4.6	0.5	0.7	156	122	31.0	8.5	0.5	162
U.L. LU 06	112	39	16	9.6	1.5	2.5	181	107	35.4	9.9	0.5	153
U.L. 6A25	106	39	24	5.2	1.1	1.9	177	119	37.5	8.5	0.7	166
Gornupkagama	116	39	13	3.2	0.6	0.9	173	92	52.7	5.6	1.6	152
U.L. MOE 09	105	30	16	1.2	0.3	0.8	153	90	56.4	6.4	0.3	153
Cascade	150	42	16	2.7	0.6	0.7	212	100	66.1	5.6	1.4	173
U.L. MOE 04*	150	82	36	5.9	0.2	1.4	276	128	68.9	5.6	0.2	203
U.L. MOE 12	138	41	16	5.2	0.7	0.7	202	90	71.9	5.6	1.4	169

TABLE 2. (Continued).

Lake	CATIONS							ANIONS				
	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	H ⁺	NH ₄ ⁺	Σ ⁺	SO ₄ ⁻⁻	HCO ₃ ⁻	Cl ⁻	NO ₃ ⁻	Σ ⁻
U.L. 6A22	151	40	25	3.8	0.5	1.0	221	114	78.3	8.5	0.8	202
U.L. LU 04	178	56	33	21	0.2	1.3	290	125	85.3	11	0.6	222
U.L. MOE 17	151	46	15	3.0	0.3	0.9	216	96	90.1	5.6	1.3	193
Mountain	185	61	29	5.1	0.2	0.7	281	132	108	8.5	0.3	249
U.L. MOE 10	181	49	26	2.0	0.2	0.7	259	116	110	8.5	0.7	235
U.L. MOE 06	166	59	15	5.0	0.2	1.1	246	101	112	5.6	1.1	220
U.L. LU 07	190	49	25	4.0	0.4	0.8	269	111	112	8.5	1.1	233
U.L. LU 02	181	56	22	5.0	0.3	1.7	266	107	113	9.4	0.8	230
U.L. MOE 05*	249	82	34	7.4	0.3	1.1	374	133	128	8.5	0.8	270
Lurch*	200	82	30	4.6	0.1	0.6	317	96	161	5.6	-	263
U.L. MOE 07	218	75	19	4.4	0.2	2.4	319	107	169	6.6	0.8	283
Widgeon*	200	82	44	5.1	0.0	0.6	332	-	194	5.6	0.2	-
U.L. MOE 11*	250	82	48	9.0	0.1	0.6	390	141	198	11	0.2	350
Buchanan	294	107	42	3.2	0.1	1.1	447	151	246	11	0.3	408
U.L. LU 03	311	96	27	5.7	0.1	0.6	440	106	282	8.5	0.3	397
U.L. LU 01	313	91	22	5.1	0.1	2.8	434	88	320	5.6	0.8	414
Caribou*	349	165	44	7.9	0.0	0.2	566	121	363	8.5	0.2	493
Lost	419	148	35	3.6	0.0	2.2	608	79	454	17	0.5	551
South Soldier*	499	82	34	5.4	0.0	0.6	621	96	538	8.5	0.2	643
Willow*	898	165	41	7.2	0.0	0.6	1112	104	972	14	-	1090
U.L. MOE 08*	1048	247	39	9.0	0.0	0.6	1344	98	1230	11	0.2	1339

*1981 data only.

TABLE 3. Comparison of Al, Mn, Zn, Cu and Cd concentrations in Norwegian, Swedish and Ontario lakes. Data from Norway and Sweden are ranges; Ontario data are means.

Locations	No. of Lakes	Al ($\mu\text{g}/\ell$)	Mn ($\mu\text{g}/\ell$)	Zn ($\mu\text{g}/\ell$)	Cu ($\mu\text{g}/\ell$)	Cd ($\mu\text{g}/\ell$)
Pukaskwa National Park	28	144	25	5	3.2	0.5
Pukaskwa National Park (acidic lakes)	2	350	56	14	6	0.9
ELA ¹	102	-	-	<1-1	1-3	0.1-0.5
NWR ³	57	40	18	-	3.5	1.4
Sudbury ¹	209	-	-	13	11	-
Sudbury ⁴	250	80	63	-	-	-
Sudbury (Clearwater L.) ²	1	380	290	39	81	0.05-0.23
Norway ¹	110	-	-	0.5-12	0.5-3	0.3
Sweden ¹	-	-	-	10-30	-	0.05-0.23
Water Quality Objectives	-	100	-	30	5	0.2

¹ From Henriksen, A. and R. F. Wright. 1978. Concentrations of heavy metals in small Norwegian lakes. Water Research. 12: 101-112.

² From Ontario Ministry of the Environment. 1978B. Extensive monitoring of lakes in the greater Sudbury area, 1974-1976.

³ From Sutton et al., 1983. In prep. Data includes only lakes west of Thunder Bay with four or more sampling occasions.

⁴ From Ontario Ministry of the Environment, unpublished data from Northeastern Region, summer, 1982. Courtesy of W. Keller.

TABLE 4. Correlation matrix of major water quality parameters for Pukaskwa National Park lakes. Data from Appendix A used to derive correlation coefficients.

[illegible]

TABLE 5. Sulphate concentrations, standard deviations and ranges in lakes across northwestern Ontario from longitude 94° 00' to 85° 55'. The percentage of lakes with colour >30 Hazen Units (H.U.) in each area is also given.

Area	No. of Lakes	Approximate Longitude	SO ₄ (mg/l)			Lakes with Colour > 30 H.U. (%)
			Mean	S	Range	
Kenora	71	94° 00'	3.6	0.84	2.0-6.4	14
Atikokan (large lakes)	99	91° 35'	4.0	0.90	2.0-7.6	42
Atikokan (small lakes)	71	91° 35'	3.1	0.94	1.0-6.1	59
Thunder Bay	86	88° 45'	4.2	1.40	0.8-8.0	41
Pays Plat	4	87° 40'	4.6	0.10	3.8-5.3	100
Pukaskwa National Park	38	85° 55'	5.2	0.87	3.8-7.5	50

TABLE 6. Mean colour values, standard deviation and number of observations for lakes located in the park and in the Atikokan area separated into groups of mean colour >30 and <30 Hazen Units (H.U.).

Group	Lake Set	Colour (H.U.)		
		Mean	S	n
Mean Colour >30 H.U.	Pukaskwa Park	50	14.2	17
	Atikokan (large)	50	14.2	17
	Atikokan (small)	101	62.2	24
Mean Colour <30 H.U.	Pukaskwa Park	22	5.52	12
	Atikokan (large)	17	7.51	20
	Atikokan (small)	22	6.00	10

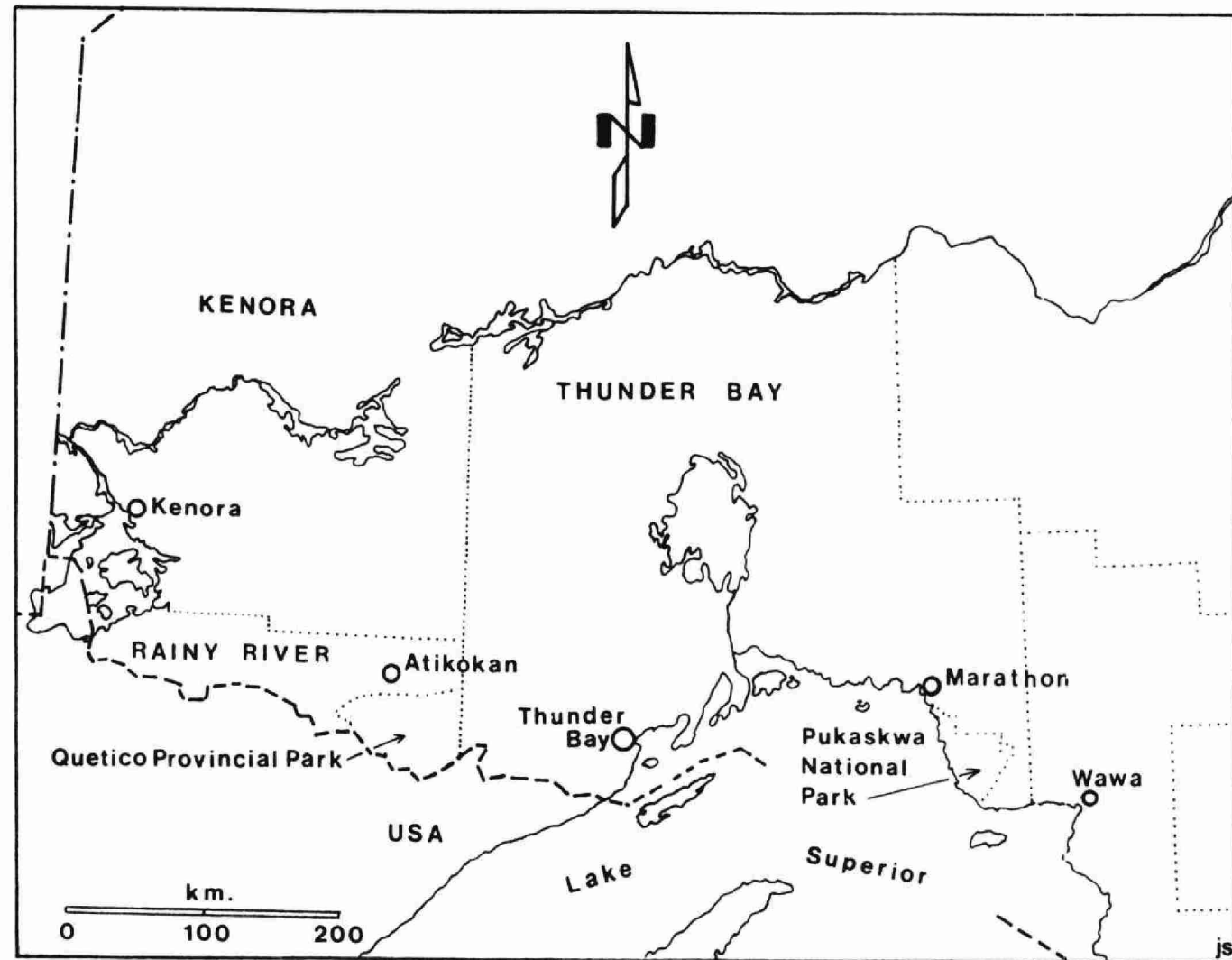


FIGURE 1. Districts, cities, towns and major parks in northwestern Ontario.

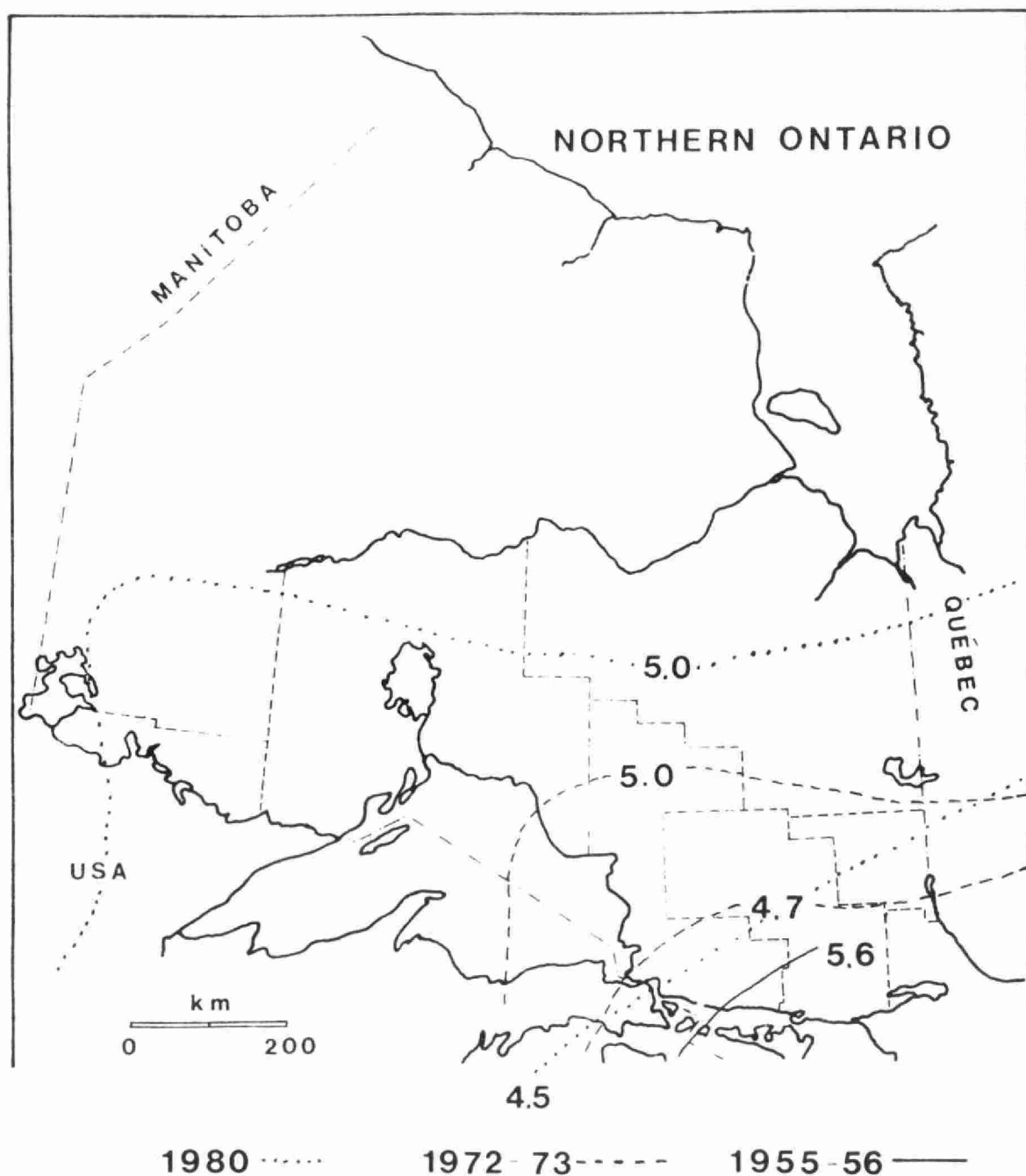
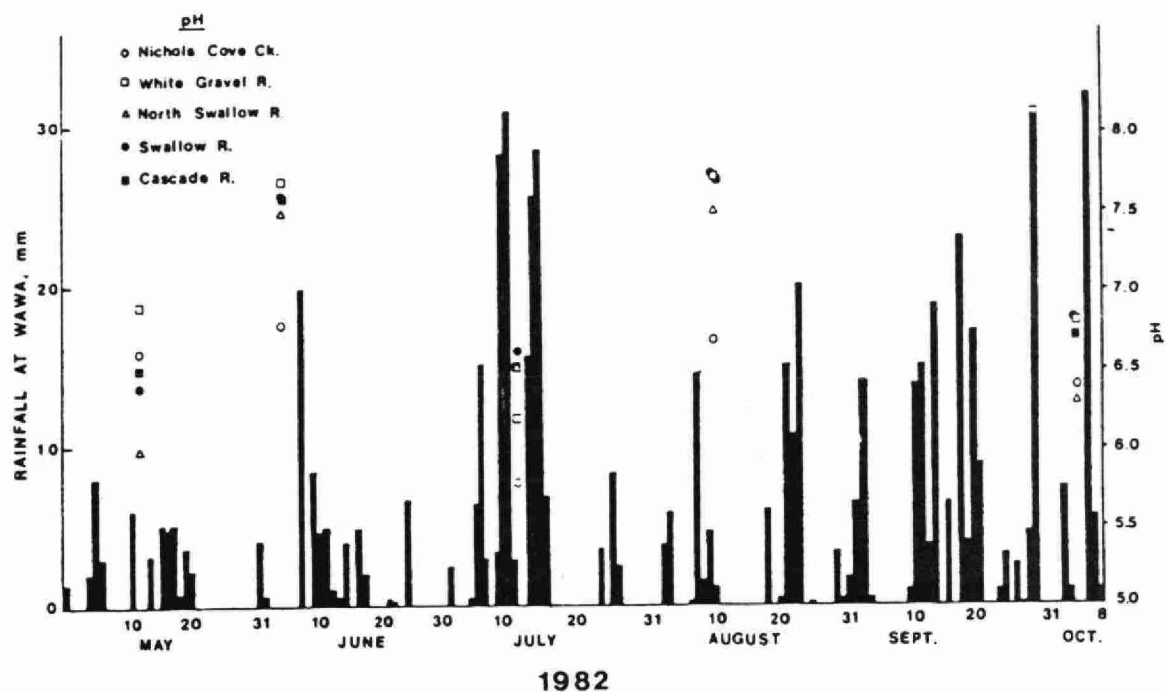


FIGURE 2. Precipitation pH trends in northwestern Ontario, 1955-56, 1972-73, and 1980 (from Cogbill, 1976; Bangay and Riordan, 1983) (1955-56 pH data are predicted, based on precipitation chemistry. 1972-73 measurements are observed annual means. 1980 data are volume-weighted means).

A



B

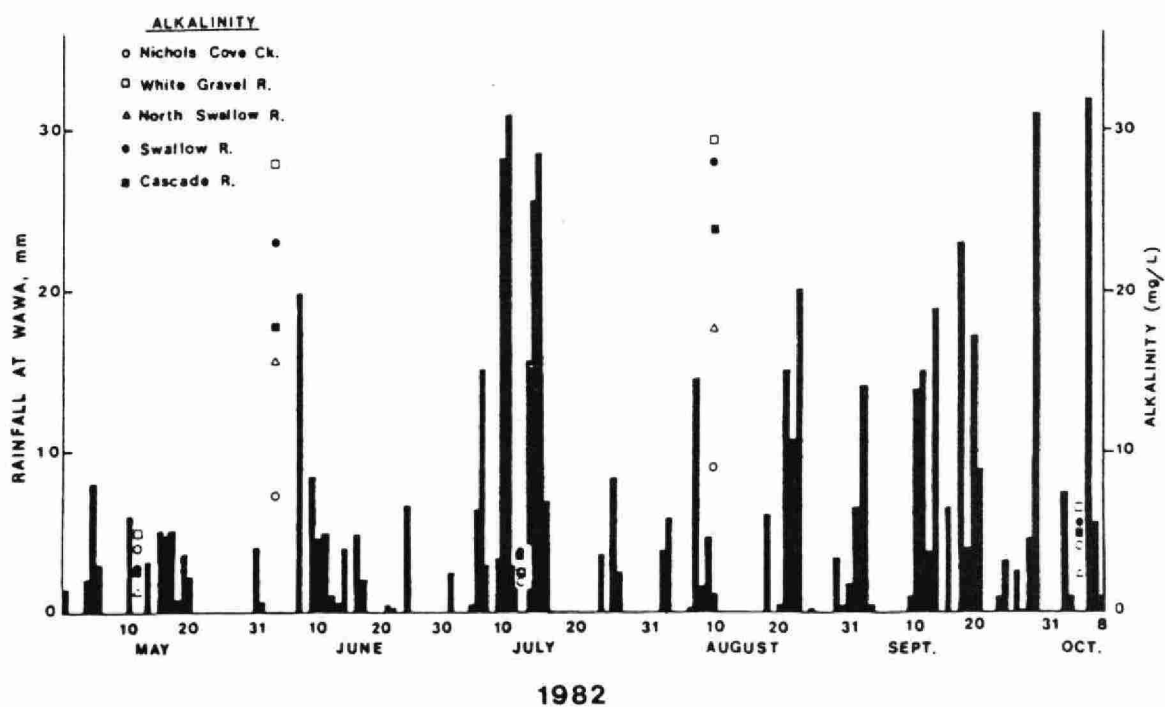


FIGURE 3. Variation of pH (A) and alkalinity (B) in Pukaskwa National Park streams with rainfall at Wawa, Ontario.

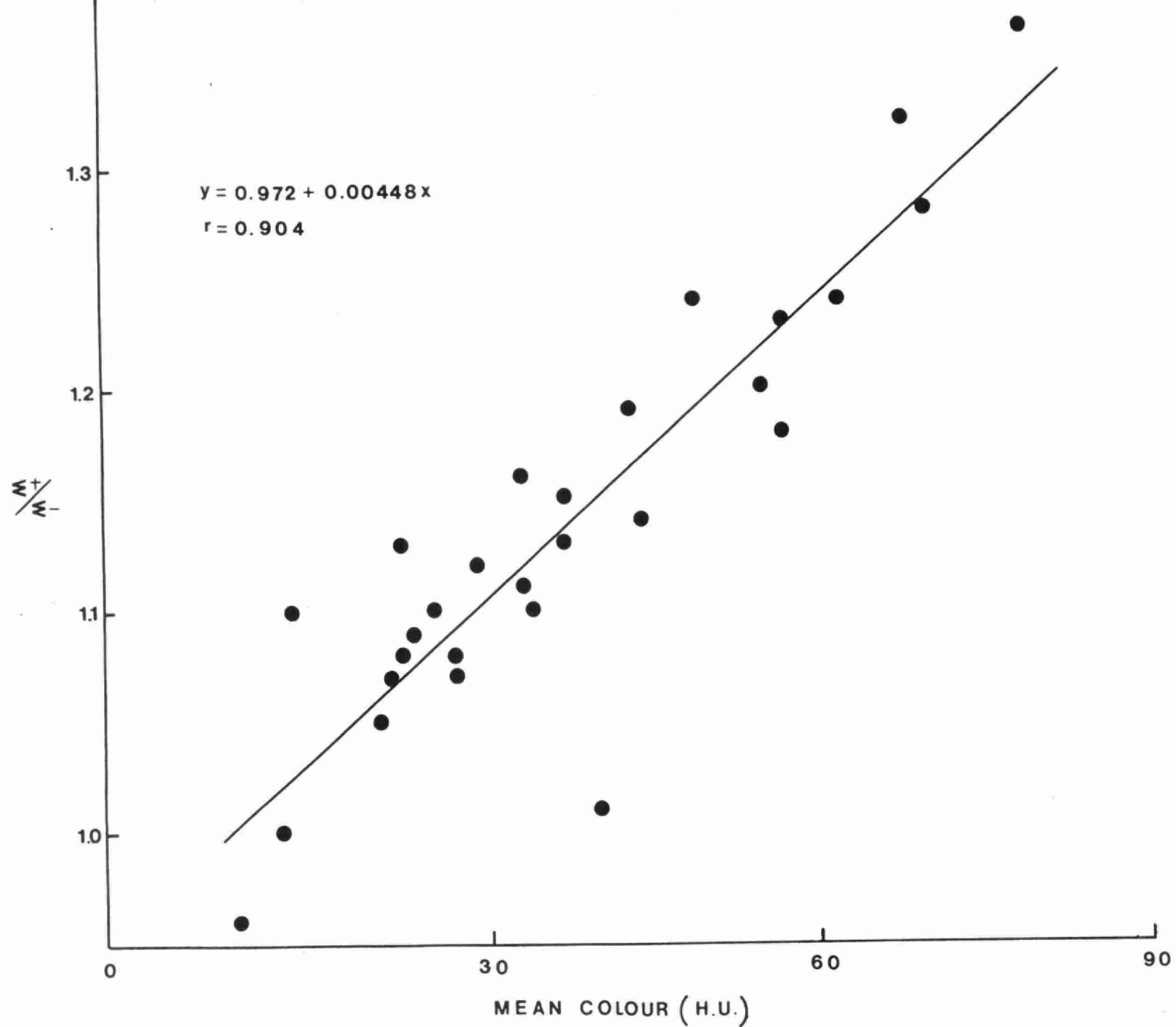


FIGURE 4. Least-squares regression line of the ratio of the cation sum (Σ^+) to the anion sum (Σ^-) as a function of mean colour for Pukaskwa National Park lakes. Only 1982 data used (Appendix A).

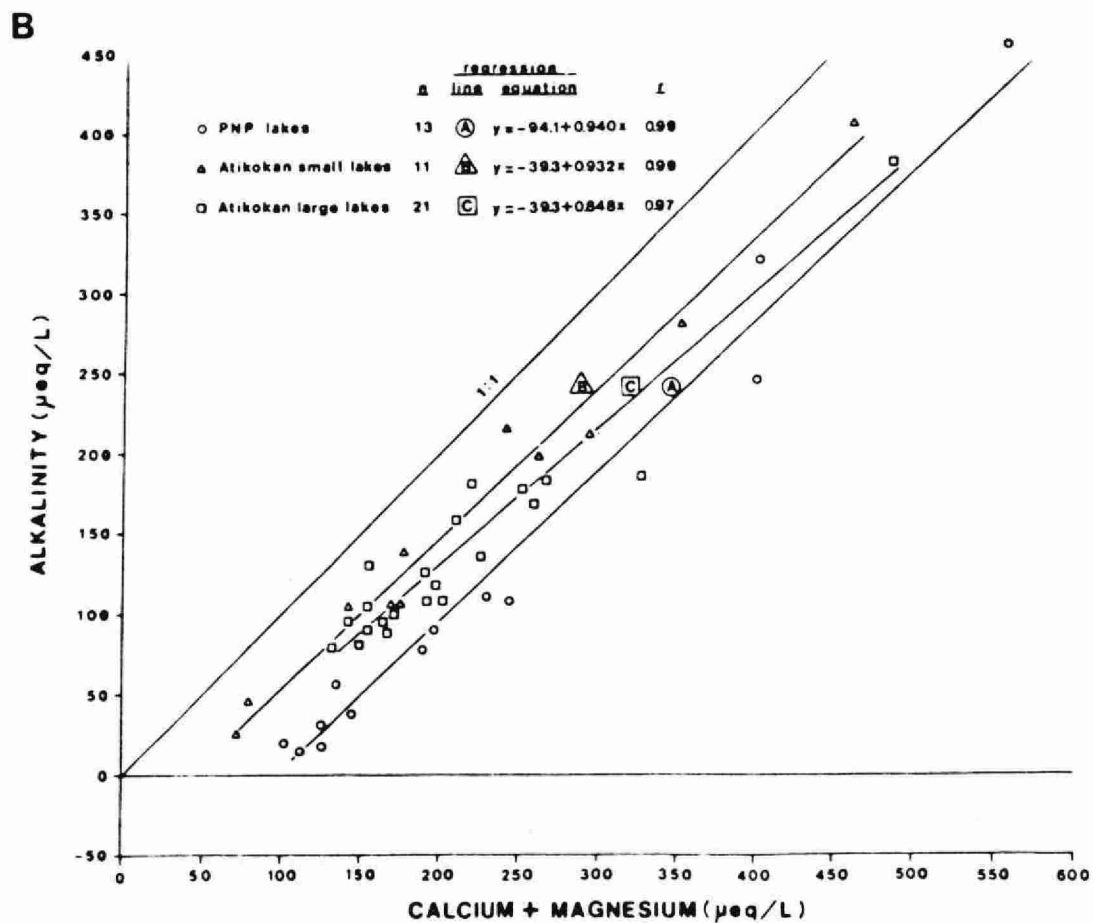
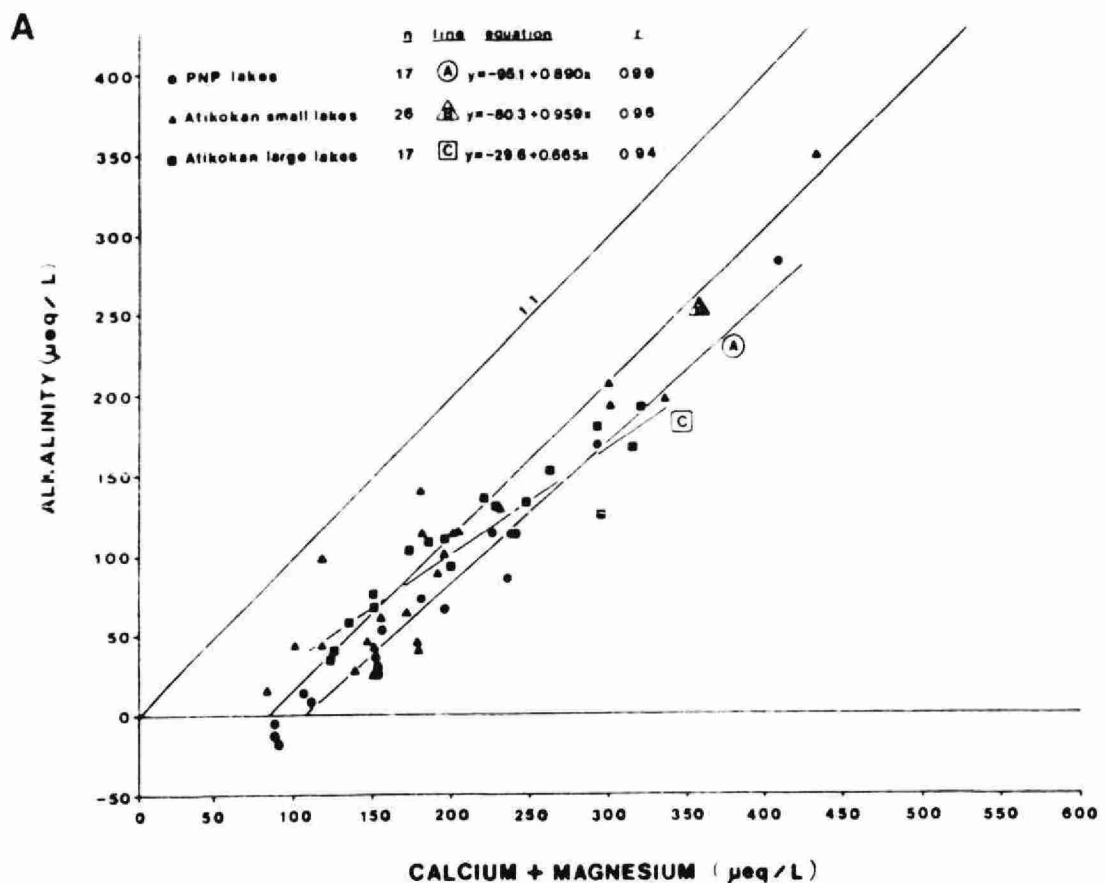


FIGURE 5. Least-squares regression lines of mean total inflection point alkalinity as a function of the sum of calcium and magnesium concentrations for Pukaskwa National Park and Atikokan area large and small lakes. (A) Lakes with mean colour measurements >30 Hazen Units; (B) Lakes with mean colour measurements <30 Hazen Units.

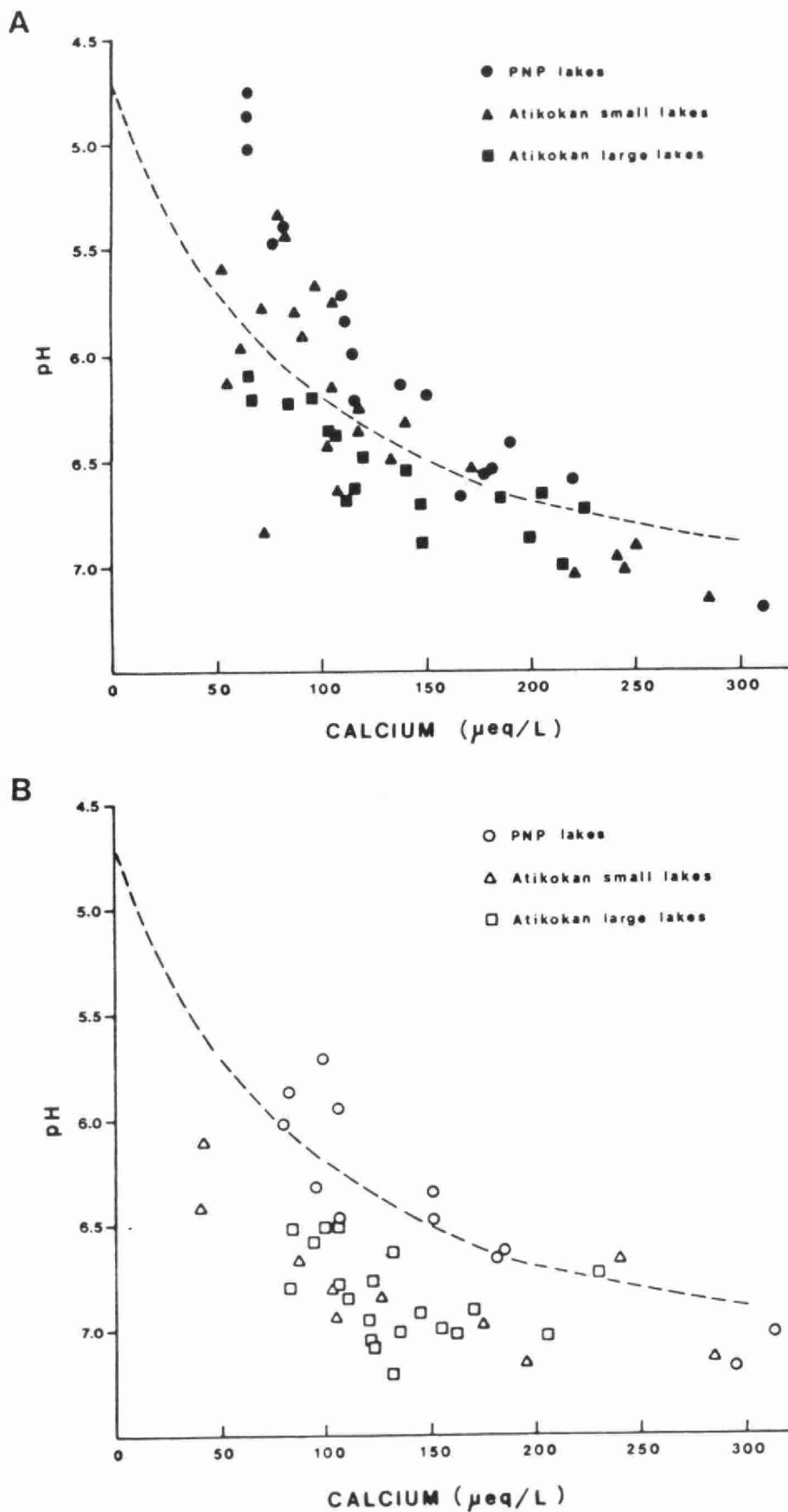


FIGURE 6. pH as a function of calcium concentration for Pukaskwa National Park and Atikokan area large and small lakes. Empirical line shown separates acid-affected (above) from unaffected lakes (from Henriksen, 1979). (A) Lakes with mean colour measurement >30 Hazen Units; (B) Lakes with mean colour measurement <30 Hazen Units.

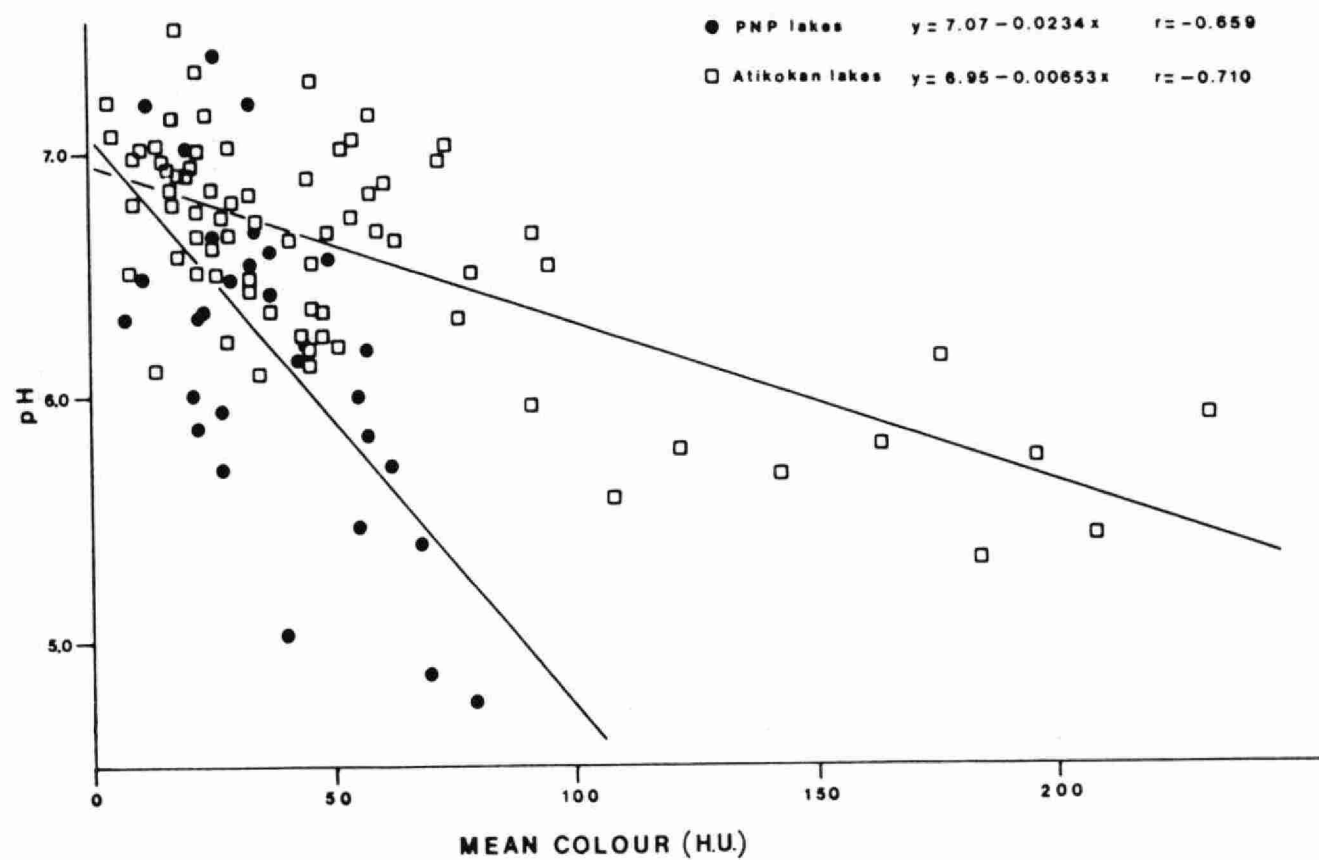


FIGURE 7. Least-squares regression lines of mean pH as a function of mean colour for Pukaskwa National Park and Atikokan area lakes.

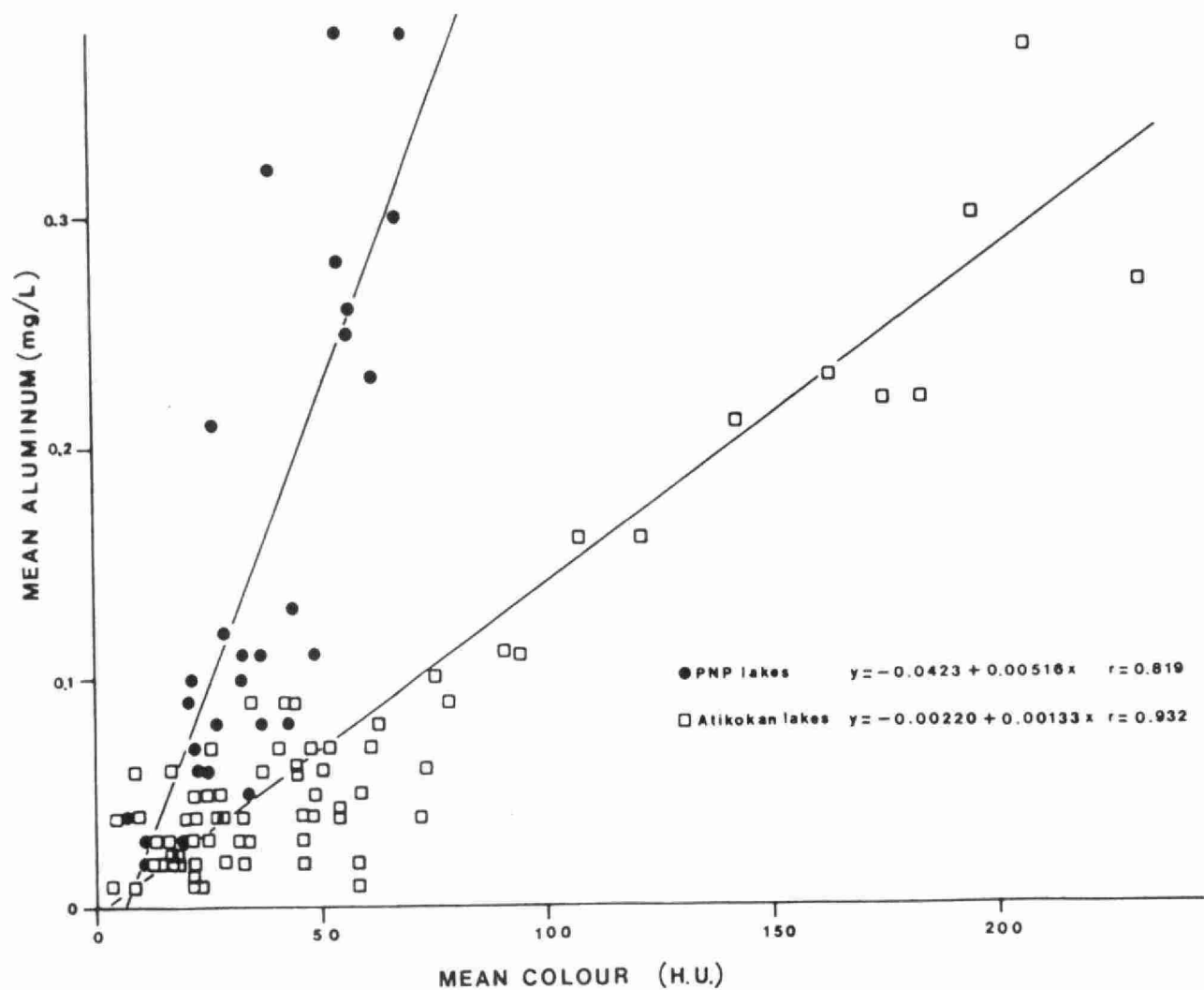


FIGURE 8. Least-squares regression lines of mean aluminum concentration as a function of mean colour for Pukaskwa National Park and Atikokan area lakes.

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APPENDIX A

Water Chemistry Data, Pukaskwa National Park lakes and streams,
1981-1982.

Parameters reported are:

- Total Inflection Point Alkalinity
- pH
- Conductivity
- Calcium
- Magnesium
- Sodium
- Potassium
- Sulphate
- Chloride
- Colour
- Silicates
- Total Phosphorous

THUNDER BAY

PAGE 1

LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l
BUCHANAN LAKE															
48.05	86.00	81/8/12	0	12.69	7.52	51	6.00	1.00	1.20	.24	8.00	.40	7	1.30	.004
		82/7/13	12	12.31	7.30	49	5.80	1.30	.92	.08	7.00	.40	12	1.40	.003
		82/10/5	12	12.28	7.08	51	6.00	1.30	1.00	.17	7.50	.40	12	1.30	.007
MEANS SIZE:				12.43 3	7.30 3	50 3	5.93 3	1.20 3	1.04 3	.16 3	7.50 3	.40 3	10 3	1.33 3	.005 3
CARIBOU LAKE															
48.28	86.12	81/8/12	0	18.13	7.42	60	7.00	2.00	1.00	.31	5.80	.30	54	.70	.012
CASCADE LAKE															
48.18	86.06	82/6/3	12	2.72	6.20	25	2.70	.43	.51	.14	4.40	.20	59	1.90	.007
		82/7/13	12	2.84	6.10	26	2.80	.56	.17	.04	4.60	.20	31	1.80	.009
		82/10/5	12	4.35	6.30	29	3.50	.54	.39	.13	5.50	.20	81	2.10	.013
MEANS SIZE:				3.30 3	6.20 3	27 3	3.00 3	.51 3	.36 3	.10 3	4.83 3	.20 3	57 3	1.93 3	.010 3
GORNUPKAGAMA LAKE															
48.18	86.06	82/6/3	12	2.60	6.20	23	2.30	.42	.42	.14	4.60	.20	45	1.90	.006
		82/7/13	12	2.66	6.20	23	2.20	.50	.20	.08	4.20	.20	41	1.20	.008
		82/10/5	12	2.65	6.25	24	2.50	.50	.26	.15	4.40	.20	45	1.20	.014
MEANS SIZE:				2.64 3	6.22 3	23 3	2.33 3	.47 3	.29 3	.12 3	4.40 3	.20 3	44 3	1.43 3	.009 3
LOST LAKE															
48.18	86.06	82/7/14	8	22.70	7.40	64	8.40	1.80	.81	.14	3.80	.60	26	.90	.007
LURCH LAKE															
48.27	85.49	81/8/12	0	8.03	7.24	32	4.00	1.00	.69	.18	4.60	.20	24	1.40	.005

PAGE 2

LATT.	WATER BODY LONG.	X SAMPLE X		PARAMETERS											
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l
MOUNTAIN LAKE															
48.12	86.06	81/8/12	0	5.67	7.11	35	4.00	1.00	.81	.29	7.00	.40	14	.80	.006
		81/9/9	12	5.27	6.50	38	4.00	< 1.00	.97	.30	7.10	.40	19	.70	.006
		82/6/3	12	5.43	6.70	34	3.80	.73	.68	.22	6.40	.30	23	.80	.007
		82/7/13	8	5.33	6.80	34	3.50	.73	.61	.14	6.00	.30	22	.70	.005
		82/10/5	12	5.37	6.40	35	3.80	.78	.74	.24	6.60	.30	20	.80	.012
MEANS SIZE:				5.41 5	6.70 5	35 5	3.82 5	.85 5	.76 5	.24 5	6.62 5	.34 5	20 5	.76 5	.007 5
PERRY LAKE															
48.05	85.47	81/8/12	0	2.52	6.65	26	3.00	< 1.00	.68	.31	5.80	.40	32	1.40	.007
		82/6/3	12	1.22	5.80	24	2.10	.42	.42	.28	5.40	.30	55	.90	.006
		82/7/13	12	1.13	5.70	24	2.20	.53	.31	.18	4.90	.30	64	1.60	.015
		82/10/5	12	1.32	5.67	25	2.40	.53	.38	.24	5.30	.30	66	1.70	.013
MEANS SIZE:				1.55 4	5.96 4	25 4	2.43 4	.62 4	.45 4	.25 4	5.35 4	.33 4	54 4	1.40 4	.010 4
SOUTH SOLDIER LAKE															
48.24	85.46	81/8/12	0	26.91	7.86	70	10.00	1.00	.77	.21	4.60	.30	7	1.40	.003
UNNAMED LAKE LU01															
48.17	85.46	82/6/3	8	15.03	7.10	48	6.30	1.10	.62	.22	4.20	.20	21	1.40	.005
		82/7/13	8	14.86	7.20	46	6.10	1.10	.29	.13	4.20	.20	16	.80	.007
		82/10/5	10	18.17	6.76	47	6.40	1.10	.59	.25	4.30	.20	23	.90	.010
MEANS SIZE:				16.02 3	7.02 3	47 3	6.27 3	1.10 3	.50 3	.20 3	4.23 3	.20 3	20 3	1.03 3	.007 3
UNNAMED LAKE LU02															
48.23	86.03	82/6/2	11	5.88	6.60	31	3.70	.65	.56	.22	5.50	.30	30	1.20	.005
		82/7/13	12	5.61	6.40	32	3.60	.66	.58	.13	4.90	.40	35	1.00	.010
		82/10/5	5	5.44	6.65	31	3.60	.73	.36	.23	5.00	.30	34	.90	.010
MEANS SIZE:				5.64 3	6.55 3	31 3	3.63 3	.68 3	.50 3	.19 3	5.13 3	.33 3	33 3	1.03 3	.008 3

THUNDER BAY

PAGE 3

LATT.	WATER BODY LONG.	* SAMPLE *			PARAMETERS											
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l	
UNNAMED LAKE LU03																
48.23	86.01	82/6/2	3	14.73	7.30	47	6.40	1.20	.70	.27	5.30	.30	30	2.30	.011	
		82/7/13	3	14.19	7.20	46	6.20	1.10	.63	.16	4.50	.30	36	2.30	.007	
		82/10/5	3	13.44	7.13	47	6.10	1.20	.50	.24	5.50	.30	33	2.50	.010	
MEANS SIZE:				14.12 3	7.21 3	47 3	6.23 3	1.17 3	.61 3	.22 3	5.10 3	.30 3	33 3	2.37 3	.009 3	
UNNAMED LAKE LU04																
48.21	86.10	82/6/3	6	4.51	6.70	33	3.60	.69	.72	.28	6.20	.40	45	1.40	.017	
		82/7/13	7	4.08	6.50	32	3.50	.69	.72	1.90	5.70	.40	50	1.70	.007	
		82/10/5	5	4.21	6.52	33	3.60	.66	.84	.26	6.10	.40	52	1.80	.013	
MEANS SIZE:				4.27 3	6.57 3	33 3	3.57 3	.68 3	.76 3	.81 3	6.00 3	.40 3	49 3	1.63 3	.012 3	
UNNAMED LAKE LU05																
48.17	86.03	82/7/14	12	-.61	4.90	22	1.20	.29	.22	.33	3.90	.20	67	1.30	.007	
		82/10/5	12	-.67	4.84	22	1.40	.25	<.20	.34	4.40	.30	73	1.50	.010	
		MEANS SIZE:		-.64 2	4.87 2	22 2	1.30 2	.27 2	.21 2	.34 2	4.15 2	.25 2	70 2	1.40 2	.009 2	
UNNAMED LAKE LU06																
48.21	85.06	82/7/14	5	1.10	5.80	25	2.00	.47	.47	.35	5.00	.30	53	1.90	.006	
		82/10/5	10	2.44	5.87	27	2.50	.47	.27	.40	5.30	.40	61	2.10	.012	
		MEANS SIZE:		1.77 2	5.84 2	26 2	2.25 2	.47 2	.37 2	.38 2	5.15 2	.35 2	57 2	2.00 2	.009 2	
UNNAMED LAKE LU07																
48.21	86.07	82/7/14	12	5.42	6.50	34	3.60	.59	.63	.13	5.20	.30	36	1.70	.006	
		82/10/5	12	5.78	6.35	34	4.00	.61	.54	.18	5.50	.30	37	1.70	.014	
		MEANS SIZE:		5.60 2	6.43 2	34 2	3.80 2	.60 2	.59 2	.16 2	5.35 2	.30 2	37 2	1.70 2	.010 2	
UNNAMED LAKE LU08																
48.15	86.03	82/7/14	8	-.94	4.75	24	1.30	.28	.16	.20	3.90	.20	79	1.40	.008	

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											P tot. mg/l	
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l		
UNNAMED LAKE LU09																
48.14	86.04	82/10/5	5	1.50	6.00	24	2.30	.45	.48	.26	5.40	.30	55	1.50	.011	
UNNAMED LAKE MOE01																
48.18	86.06	81/9/9	5	.11	5.49	21	2.00	< 1.00	.60	.26	5.90	.20	20	.90	.005	
		82/6/3	9	-.11	5.10	23	1.30	.25	.51	.14	5.40	.20	42	1.80	.005	
		82/7/13	8	-.43	5.00	22	1.30	.31	.29	.09	4.90	.20	41	1.30	.006	
		82/10/5	4	-.44	5.00	21	1.30	.25	.22	.15	5.20	.30	38	1.20	.010	
MEANS SIZE:				-.22 4	5.15 4	22 4	1.48 4	.45 4	.41 4	.16 4	5.35 4	.23 4	35 4	1.30 4	.007 4	
UNNAMED LAKE MOE02																
48.17	86.05	81/9/9	12	.96	5.66	25	2.00	< 1.00	.66	.34	6.10	.20	22	1.80	.004	
		82/6/3	12	1.17	5.80	21	2.10	.33	.49	.22	5.90	.30	29	1.40	.003	
		82/7/13	12	.86	5.70	23	1.90	.34	.45	.15	5.30	.30	27	1.80	.004	
		82/10/5	12	.69	5.62	23	1.90	.33	.32	.23	5.40	.30	26	1.80	.007	
MEANS SIZE:				.92 4	5.70 4	23 4	1.98 4	.50 4	.48 4	.24 4	5.68 4	.28 4	26 4	1.70 4	.005 4	
UNNAMED LAKE MOE03																
48.18	85.55	81/9/9	12	.68	5.39	22	2.00	< 1.00	.52	.17	4.10	.20	53	1.10	.007	
		82/6/2	12	.75	5.60	20	1.60	.34	.45	.09	4.60	.20	59	1.20	.006	
		82/7/13	10	.30	5.30	20	1.60	.31	.25	.04	3.90	.10	71	1.10	.008	
		82/10/5	12	.27	5.31	20	1.70	.44	< .20	.08	3.70	.20	75	1.10	.012	
MEANS SIZE:				.50 4	5.40 4	21 4	1.73 4	.52 4	.36 4	.10 4	4.08 4	.18 4	65 4	1.13 4	.008 4	
UNNAMED LAKE MOE04																
48.19	85.49	81/8/12	0	3.65	6.80	27	3.00	< 1.00	1.00	.24	5.80	.20	14	.50	.008	
		81/9/9	2	3.24	6.66	28	3.00	< 1.00	.66	.22	6.50	.20	14	.30	.008	
MEANS SIZE:				3.45 2	6.73 2	28 2	3.00 2	1.00 2	.83 2	.23 2	6.15 2	.20 2	14 2	.40 2	.008 2	
UNNAMED LAKE MOE05																
48.08	85.53	81/9/9	12	6.42	6.52	38	5.00	< 1.00	.77	.29	6.40	.30	37	1.40	.005	

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l
UNNAMED LAKE MOE06															
(SECRET L.)															
48.12	85.32	82/6/3	7	5.76	6.70	30	3.30	.69	.39	.22	5.20	.20	33	1.80	.008
		82/7/13	7	5.49	6.60	30	3.30	.69	.26	.14	4.60	.20	33	.90	.009
		82/10/5	6	5.57	6.75	30	3.40	.76	.39	.22	4.80	.20	36	.90	.023
MEANS				5.61	6.68	30	3.33	.71	.35	.19	4.87	.20	34	1.20	.013
SIZE:				3	3	3	3	3	3	3	3	3	3	3	3
UNNAMED LAKE MOE07															
48.18	86.06	82/6/3	12	8.68	6.50	37	4.30	.91	.43	.19	5.20	.30	37	1.20	.005
		82/7/13	12	8.33	6.50	37	4.30	.91	.37	.12	4.90	.20	36	1.80	.007
		82/10/5	8	8.34	6.79	36	4.50	.93	.48	.20	5.40	.20	39	1.70	.013
MEANS				8.45	6.60	37	4.37	.92	.43	.17	5.17	.23	37	1.57	.008
SIZE:				3	3	3	3	3	3	3	3	3	3	3	3
UNNAMED LAKE MOE08															
48.28	86.02	81/9/9	6	61.51	7.72	138	21.00	3.00	.89	.35	4.70	.40	22	1.40	.006
UNNAMED LAKE MOE09															
48.24	86.06	81/9/9	7	3.00	6.69	25	3.00	< 1.00	.69	.18	4.70	.20	6	.40	.004
		82/6/2	12	2.95	6.50	22	2.20	.37	.43	< .04	4.90	.20	14	.70	.004
		82/7/13	12	2.80	6.60	22	2.10	.35	.46	< .04	4.10	.30	12	.60	.006
		82/7/14	12	2.82	6.40	22	1.90	.34	.31	.04	4.00	.20	6	.60	.005
		82/10/5	12	2.71	6.47	22	2.20	.42	.28	.06	4.30	.20	10	.50	.009
MEANS				2.86	6.53	23	2.28	.50	.43	.07	4.40	.22	10	.56	.006
SIZE:				5	5	5	5	5	5	5	5	5	5	5	5
UNNAMED LAKE MOE10															
48.14	86.07	81/9/9	12	5.40	6.44	33	3.00	1.00	.85	.22	6.40	.30	18	.70	.008
		82/6/3	12	5.30	6.70	32	3.50	.59	.66	.08	5.80	.30	25	1.10	.006
		82/7/13	12	5.05	6.50	31	3.50	.60	.61	< .04	5.30	.30	24	.70	.007
		82/10/5	12	6.11	6.79	33	3.90	.61	.52	.11	5.70	.30	26	.80	.009
MEANS				5.47	6.61	32	3.48	.70	.66	.11	5.80	.30	23	.83	.008
SIZE:				4	4	4	4	4	4	4	4	4	4	4	4
UNNAMED LAKE MOE11															
48.06	85.57	81/9/9	3	9.92	7.12	46	5.00	1.00	1.10	.35	6.80	.40	23	.90	.008

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l
UNNAMED LAKE MOE12															
48.11	85.44	82/6/3	7	3.56	6.30	25	2.70	.48	.45	.22	4.00	.20	43	1.10	.007
		82/7/13	12	3.47	6.10	26	2.50	.55	.29	.14	4.40	.20	40	1.10	.008
		82/10/5	10	3.75	6.06	28	3.10	.45	.34	.25	4.60	.20	45	1.10	.011
MEANS SIZE:				3.59 3	6.15 3	26 3	2.77 3	.49 3	.36 3	.20 3	4.33 3	.20 3	43 3	1.10 3	.009 3
UNNAMED LAKE MOE16															
48.22	85.54	81/9/9	12	.13	5.19	21	2.00	< 1.00	.51	.21	4.40	.20	49	1.80	.006
		82/6/2	12	.80	5.60	19	1.50	.29	.46	.11	4.50	.10	52	1.80	.007
		82/7/13	12	.55	5.40	20	1.50	.27	.36	.04	3.90	.20	55	1.80	.005
		82/10/5	12	.64	5.41	20	1.70	.47	< .20	.13	4.20	.20	58	1.90	.011
MEANS SIZE:				.53 4	5.40 4	20 4	1.68 4	.51 4	.38 4	.12 4	4.25 4	.18 4	54 4	1.83 4	.007 4
UNNAMED LAKE MOE17															
48.13	85.48	82/6/3	10	4.58	6.40	28	3.10	.56	.41	.14	4.30	.20	27	1.30	.005
		82/7/13	12	4.48	6.40	27	2.90	.60	.29	.08	4.70	.20	30	1.80	.006
		82/10/5	7	4.46	6.63	27	3.10	.50	.33	.13	4.90	.20	29	1.90	.010
MEANS SIZE:				4.51 3	6.48 3	27 3	3.03 3	.55 3	.34 3	.12 3	4.63 3	.20 3	29 3	1.67 3	.007 3
UNNAMED LAKE 6A22															
48.22	86.09	81/9/9	12	4.06	6.19	30	3.00	1.00	.86	.27	6.00	.20	17	1.00	.004
		82/6/2	12	4.01	6.40	29	3.20	.41	.67	.15	5.00	.30	23	1.20	.009
		82/6/3	12	4.09	6.40	29	3.00	.49	.63	.14	5.60	.30	26	1.00	.004
		82/7/14	12	3.87	6.35	29	2.90	.44	.49	.14	5.30	.30	21	1.10	.006
		82/10/5	12	3.68	6.23	29	3.00	.62	.49	.17	6.00	.30	23	1.10	.016
MEANS SIZE:				3.94 5	6.31 5	29 5	3.02 5	.59 5	.63 5	.17 5	5.58 5	.28 5	22 5	1.08 5	.008 5
UNNAMED LAKE 6A24															
48.22	86.09	81/9/9	2	.81	5.95	23	2.00	< 1.00	.78	.31	5.80	.30	17	< .10	.012
		82/6/2	3	.82	6.00	21	1.70	.36	.60	.23	5.60	.30	22	.60	.005
		82/7/13	4	.47	5.70	21	1.50	.40	.54	.18	5.10	.30	19	.30	.010
		82/10/5	2	.76	5.90	22	1.80	.34	.56	.23	5.50	.30	24	.50	.012
MEANS SIZE:				.72 4	5.89 4	22 4	1.75 4	.53 4	.62 4	.24 4	5.50 4	.30 4	21 4	.38 4	.010 4

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l
UNNAMED LAKE 6A25															
48.22	86.09	81/8/12	0	1.58	6.43	24	3.00	< 1.00	.77	.28	6.10	.30	13	.70	.007
		81/9/9	12	1.66	5.70	27	3.00	< 1.00	.79	.26	6.20	.30	24	.80	.006
		82/6/3	10	1.66	5.90	25	2.10	.47	.62	.18	5.90	.30	26	1.90	.004
		82/7/14	12	1.96	5.85	26	2.10	.48	.41	.20	5.30	.30	27	.90	.008
		82/10/5	10	2.01	6.11	25	2.20	.47	.62	.23	6.00	.30	29	.60	.012
MEANS SIZE:				1.77 5	6.00 5	25 5	2.48 5	.68 5	.64 5	.23 5	5.90 5	.30 5	24 5	.98 5	.007 5
UNNAMED LAKE 6A27															
48.22	86.08	81/9/9	12	1.45	6.27	24	2.00	< 1.00	.69	.31	6.20	.20	6	.30	.007
		82/6/2	12	1.77	6.50	23	2.00	.41	.54	.16	6.80	.30	8	.50	.004
		82/7/13	12	1.47	6.20	23	1.90	.39	.54	.16	5.10	.30	6	.50	.004
		82/10/5	12	1.42	6.27	22	1.80	.33	.54	.22	5.70	.30	6	.50	.008
MEANS SIZE:				1.53 4	6.31 4	23 4	1.93 4	.53 4	.58 4	.21 4	5.95 4	.28 4	7 4	.45 4	.006 4
UNNAMED LAKE 6D14															
48.26	85.47	81/9/9	10	.61	5.86	19	2.00	< 1.00	.61	.10	4.10	.10	12	< .10	.008
		82/6/2	2	1.52	6.40	18	1.80	.27	.35	< .04	4.40	.20	17	.50	.008
		82/7/13	10	.61	5.70	18	1.40	.22		.04	3.70	.10		.30	.010
		82/10/5	12	1.00	5.93	19	1.60	.32	< .20	< .04	4.00	.20	25	.30	.017
MEANS SIZE:				.94 4	5.97 4	19 4	1.70 4	.45 4	.39 3	.06 4	4.05 4	.15 4	18 3	.30 4	.011 4
WIDGEON LAKE															
48.16	85.33	81/8/12	0	9.69	7.68	37	4.00	1.00	1.00	.20		.20	8	.30	.006
WILLOW LAKE															
48.28	86.01	81/8/12	0	48.60	7.96	111	18.00	2.00	.95	.28	5.00	.50	29	1.60	.004

THUNDER BAY

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WATER BODY		* SAMPLE *		PARAMETERS											
LATT.	LONG.	DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l
CASCADE RIVER															
48.08	86.03	82/5/12	0	2.56	6.50	23									
		82/5/13	0	2.64	6.50	23						5.10			
		82/6/3	0	17.79	7.60	56									
		82/7/13	0	3.46	6.50	27						4.40			
		82/8/10	0	23.61	7.70	67	9.20	1.60	.83	.08	4.70	.70	35	2.00	.010
		82/10/5	0	4.67	6.69	31	3.80	.60	.52	.12	5.40	.40	80	2.50	.010
MEANS				9.12	6.92	38	6.50	1.10	.68	.10	4.90	.55	58	2.25	.010
SIZE:				6	6	6	2	2	2	2	4	2	2	2	2
NICHOLS COVE CREEK															
48.23	86.11	82/5/12	0	3.88	6.60	31									
		82/5/13	0	4.21	6.70	31						7.00			
		82/6/3	0	7.27	6.80	36									
		82/7/13	0	1.84	5.80	33						6.80			
		82/8/10	0	8.96	6.70	39	4.70	.74	.97	.09		.40	43	2.10	.011
		82/10/5	0	4.08	6.42	35	4.30	.61	.84	.15	7.10	.40	69	3.10	.011
MEANS				5.04	6.50	34	4.50	.68	.91	.12	6.97	.40	56	2.60	.011
SIZE:				6	6	6	2	2	2	2	3	2	2	2	2
NORTH SWALLOW RIVER															
48.13	86.06	82/5/12	0	1.33	6.00	22									
		82/5/13	0	1.33	6.10	22						5.20			
		82/6/3	0	15.16	7.50	52									
		82/7/13	0	2.42	6.50	25						4.90			
		82/8/10	0	17.80	7.50	57	7.10	2.20	.89	.13	5.10	1.20	41	1.80	.012
		82/10/5	0	2.23	6.34	26	2.60	.45	.50	.24	5.50	.30	66	2.00	.012
MEANS				6.71	6.66	34	4.85	1.33	.70	.19	5.18	.75	54	1.90	.012
SIZE:				6	6	6	2	2	2	2	4	2	2	2	2
OISEAU CREEK															
48.24	86.11	82/5/12	0	25.35	7.60	71									
		82/5/13	0	29.30	7.70	79						6.30			
MEANS				27.33	7.65	75					6.30				
SIZE:				2	2	2					1				

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE * <-----		PARAMETERS ----->											
		DATE yr/mo/dy	DEPTH M	T.I.A. mg/l	pH	COND uS/cm	Ca++ mg/l	Mg++ mg/l	Na+ mg/l	K+ mg/l	SO4= mg/l	Cl- mg/l	COLOUR H.U.	SiO2 mg/l	P tot. mg/l
SWALLOW RIVER															
48.10	86.05	82/5/12	0	2.52	6.40	22									
		82/5/13	0	2.73	6.50	23					4.90				
		82/6/3	0	22.99	7.60	66									
		82/7/13	0	3.64	6.60	26					4.20				
		82/8/10	0	27.94	7.70	78	9.90	2.50	1.00	.09	5.10	.50	43	2.40	.010
		82/10/5	0	5.36	6.81	31	3.60	.72	.55	.17	5.30	.40	77	2.50	.011
MEANS SIZE:				10.86 6	6.94 6	41 6	6.75 2	1.61 2	.78 2	.13 2	4.88 4	.45 2	60 2	2.45 2	.011 2
WHITE GRAVEL RIVER															
48.18	86.09	82/5/12	0	4.90	6.90	28									
		82/5/13	0	4.58	6.80	27					5.20				
		82/6/3	0	27.69	7.70	78									
		82/7/13	0	2.39	6.20	26					4.60				
		82/8/10	0	29.37	7.70	81	11.00	2.20	.93	.12	5.60	.60	31	2.30	.006
		82/10/5	0	6.40	6.83	35	4.50	.77	.61	.21	5.60	.40	77	2.60	.013
MEANS SIZE:				12.56 6	7.02 6	46 6	7.75 2	1.49 2	.77 2	.17 2	5.25 4	.50 2	54 2	2.45 2	.010 2

APPENDIX B

Water Chemistry Data, Pukaskwa National Park lakes and streams,
1981-1982.

Parameters reported are:

- Ammonia
- Total Kjeldahl Nitrogen
- Nitrite
- Nitrate
- Lead
- Nickel
- Aluminum
- Manganese
- Iron
- Copper
- Zinc
- Cadmium

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WATER BODY		X SAMPLE		PARAMETERS											
LATT.	LONG.	DATE	DEPTH	NH4	TKN	NO2	NO3	Pb	Ni	Al	Mn	Fe	Cu	Zn	Cd
		yr/mo/day	M	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BUCHANAN LAKE															
48.05	86.00	81/8/12	0	<.01	.16	<.001	<.01								
		82/7/13	12	.03	.20	.001	.03	<.003	<.002	.01	.004	.012	.002	<.002	<.0005
		82/10/5	12	<.01	.21	<.001	<.01	.004	<.002	.02	.002	.014	.001	<.001	<.0005
MEANS SIZE:				.02 3	.19 3	.001 3	.02 3	.004 2	.002 2	.02 2	.003 2	.013 2	.002 2	.002 2	.0005 2
CARIBOU LAKE															
48.28	86.12	81/8/12	0	.03	.35	.002	<.01								
CASCADE LAKE															
48.18	86.06	82/6/3	12	<.01	.28	.003	.10	<.003	.002	.20	.022	.093	.002	.008	.0013
		82/7/13	12	.02	.32	.003	.09	<.003	.002	.31	.025	.099	.006	.009	<.0005
		82/10/5	12	.01	.34	.003	.08	<.003	<.002	.25	.017	.110	.006	.007	<.0005
MEANS SIZE:				.01 3	.31 3	.003 3	.09 3	.003 3	.002 3	.25 3	.021 3	.101 3	.005 3	.008 3	.0008 3
GORNUPKAGAMA LAKE															
48.18	86.06	82/6/3	12	.01	.26	.002	.15	<.003	<.002	.12	.043	.120	.003	.005	.0010
		82/7/13	12	.03	.26	.002	.08								
		82/10/5	12	.01	.27	.002	.07	<.003	<.002	.13	.021	.078	.018	.004	<.0005
MEANS SIZE:				.02 3	.26 3	.002 3	.10 3	.003 2	.002 2	.13 2	.032 2	.099 2	.011 2	.005 2	.0008 2
LOST LAKE															
48.18	86.06	82/7/14	8	.04	.28	.002	.03								
LURCH LAKE															
48.27	85.49	81/8/12	0	<.01	.22	.001	.00								

THUNDER BAY

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WATER BODY		* SAMPLE *		PARAMETERS												
LATT.	LONG.	DATE yr/mo/dy	DEPTH M	NH4 mg/l	TKN mg/l	NO2 mg/l	NO3 mg/l	Pb mg/l	Ni mg/l	Al mg/l	Mn mg/l	Fe mg/l	Cu mg/l	Zn mg/l	Cd mg/l	
MOUNTAIN LAKE																
48.12	86.06	81/8/12	0	.01	.23	.001	<.01									
		81/9/9	12	<.01	.23	.001	<.01									
		82/6/3	12	<.01	.29	.001	.02	<.003	.003	.05	.018	.120	<.001	.003	.0012	
		82/7/13	8	.02	.29	<.001	.02									
		82/10/5	12	.01	.29	.001	.01	<.003	<.002	.08	.023	.050	.002	.003	<.0005	
MEANS				.01	.27	.001	.01	.003	.003	.07	.021	.085	.002	.003	.0009	
SIZE:				5	5	5	5	2	2	2	2	2	2	2	2	
PERRY LAKE																
48.05	85.47	81/8/12	0	.01	.23	.002	<.01									
		82/6/3	12	<.01	.28	.003	.16	<.003	<.002	.19	.034	.150	.002	.009	.0008	
		82/7/13	12	.03	.37	.003	.13	<.003	<.002	.24	.034	.130	.003	.008	<.0005	
		82/10/5	12	.01	.32	.002	.10	.005	<.002	.25	.038	.140	.008	.008	<.0005	
MEANS				.02	.30	.003	.10	.004	.002	.23	.035	.140	.004	.008	.0006	
SIZE:				4	4	4	4	3	3	3	3	3	3	3	3	
SOUTH SOLDIER LAKE																
48.24	85.46	81/8/12	0	<.01	.15	.001	<.01									
UNNAMED LAKE LU01																
48.17	85.46	82/6/3	8	.07	.31	.002	.08	<.003	<.002	.02	.016	.035	<.001	.002	<.0005	
		82/7/13	8	.04	.26	.001	.07	<.003	<.002	.03	.180	.300	.001	.002	<.0005	
		82/10/5	10	.04	.29	.001	<.01	<.003	<.002	.03	.180	.300	.001	.002	<.0005	
MEANS				.05	.29	.001	.05	.003	.002	.03	.098	.168	.001	.002	.0005	
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2	
UNNAMED LAKE LU02																
48.23	86.03	82/6/2	11	.01	.29	.002	.07	<.003	<.002	.12	.020	.079	.001	.004	<.0005	
		82/7/13	12	.06	.34	.002	.07									
		82/10/5	5	.02	.33	.001	.01	.003	.002	.08	.018	.100	.001	<.001	<.0005	
MEANS				.03	.32	.002	.05	.003	.002	.10	.019	.090	.001	.003	.0005	
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2	

THUNDER BAY

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WATER BODY		X SAMPLE X<		PARAMETERS----->											
LATT.	LONG.	DATE yr/mo/dy	DEPTH M	NH4 mg/l	TKN mg/l	NO2 mg/l	NO3 mg/l	Pb mg/l	Ni mg/l	Al mg/l	Mn mg/l	Fe mg/l	Cu mg/l	Zn mg/l	Cd mg/l
UNNAMED LAKE LU03															
48.23	86.01	82/6/2	3	<.01	.30	.002	.04	<.003	<.002	.11	.008	.041	.001	.002	.0008
		82/7/13	3	<.01	.26	.001	.02								
		82/10/5	3	<.01	.26	.001	<.01	.005	<.002	.10	.005	.037	.001	<.001	<.0005
MEANS				.01	.27	.001	.02	.004	.002	.11	.007	.039	.001	.002	.0007
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2
UNNAMED LAKE LU04															
48.21	86.10	82/6/2	3	.01	.30	.002	.04	<.003	<.002	.11	.008	.041	.001	.002	.0008
		82/7/13	3	.01	.26	.001	.02								
		82/10/5	3	.01	.26	.001	<.01	.005	<.002	.10	.005	.037	.001	.001	<.0005
MEANS				.01	.27	.001	.02	.004	.002	.11	.007	.039	.001	.002	.0007
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2
UNNAMED LAKE LU05															
48.17	86.03	82/7/14	12	.05	.28	.003	.06								
		82/10/5	12	.04	.32	.003	.04	<.003	.008	.38	.039	.170	.003	.012	.0010
		MEANS		.05	.30	.003	.05	.003	.008	.38	.039	.170	.003	.012	.0010
SIZE:				2	2	2	2	1	1	1	1	1	1	1	1
UNNAMED LAKE LU06															
48.21	85.06	82/7/14	5	.02	.26	.002	.05								
		82/10/5	10	.07	.38	.002	.01	.006	<.002	.26	.043	.470	.001	.005	<.0005
		MEANS		.05	.32	.002	.03	.006	.002	.26	.043	.470	.001	.005	.0005
SIZE:				2	2	2	2	1	1	1	1	1	1	1	1
UNNAMED LAKE LU07															
48.21	86.07	82/7/14	12	.02	.21	.002	.07								
		82/10/5	12	<.01	.27	.002	.07	<.003	<.002	.11	.016	.063	.002	.002	<.0005
		MEANS		.02	.24	.002	.07	.003	.002	.11	.016	.063	.002	.002	.0005
SIZE:				2	2	2	2	1	1	1	1	1	1	1	1
UNNAMED LAKE LU08															
48.15	86.03	82/7/14	8	.01	.29	.003	.02								

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE yr/mo/dy	DEPTH M	NH4 mg/l	TKN mg/l	NO2 mg/l	NO3 mg/l	Pb mg/l	Ni mg/l	Al mg/l	Mn mg/l	Fe mg/l	Cu mg/l	Zn mg/l	Cd mg/l
UNNAMED LAKE LU09															
48.14	86.04	82/10/5	5	.01	.30	.002	.02	.006	<.002	.28	.025	.100	.005	.007	<.0005
UNNAMED LAKE MOE01															
48.18	86.06	81/9/9	5	<.01	.19	.001	<.01								
		82/6/3	9	.02	.27	.002	.06	<.003	<.002	.30	.075	.350	.016	.015	.0008
		82/7/13	8	.02	.21	.002	.05	<.003	<.002	.34	.074	.110	.005	.011	<.0005
		82/10/5	4	.02	.29	.002	.02	<.003	.010	.32	.071	.150	.004	.018	.0008
MEANS SIZE:				.02 4	.24 4	.002 4	.04 4	.003 3	.005 3	.32 3	.073 3	.203 3	.008 3	.015 3	.0007 3
UNNAMED LAKE MOE02															
48.17	86.05	81/9/9	12	.04	.23	.001	.07								
		82/6/3	12	.07	.29	.002	.08	<.003	<.002	.22	.091	.200	<.001	.010	.0013
		82/7/13	12	.06	.28	<.001	.11	<.003	<.002	.18	.077	.110	.005	.011	<.0005
		82/10/5	12	.04	.26	.001	.06	.003	.030	.22	.067	.076	.006	.020	<.0005
MEANS SIZE:				.05 4	.27 4	.001 4	.08 4	.003 3	.011 3	.21 3	.078 3	.129 3	.004 3	.014 3	.0008 3
UNNAMED LAKE MOE03															
48.18	85.55	81/9/9	12	.05	.31	.005	.11								
		82/6/2	12	.02	.31	.003	.16	<.003	<.002	.28	.036	.190	<.001	.009	<.0005
		82/7/13	10	.04	.37	.003	.01	<.003	<.002	.25	.031	.130	.007	.010	<.0005
		82/10/5	12	.03	.40	.003	.06	<.003	.004	.37	.028	.190	.003	.013	<.0005
MEANS SIZE:				.04 4	.35 4	.004 4	.09 4	.003 3	.003 3	.30 3	.032 3	.170 3	.004 3	.011 3	.0005 3
UNNAMED LAKE MOE04															
48.19	85.49	81/8/12	0	.03	.30	.001	<.01								
		81/9/9	2	.02	.29	.001	<.01								
MEANS SIZE:				.03 2	.30 2	.001 2	.01 2								
UNNAMED LAKE MOE05															
48.08	85.53	81/9/9	12	.02	.24	.003	.05								

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE	DEPTH	NH4	TKN	NO2	NO3	Pb	Ni	Al	Mn	Fe	Cu	Zn	Cd
		yr/mo/dy	M	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
UNNAMED LAKE MOE06															
(SECRET L.)															
48.12 85.32		82/6/3	7	<.01	.29	.002	.14	<.003	<.002	.06	.007	.045	.007	.004	.0009
		82/7/13	7	.03	.29	.001	.05								
		82/10/5	6	.02	.35	.001	.02	.005	<.002	.04	.008	.062	.006	.004	.0013
MEANS				.02	.31	.001	.07	.004	.002	.05	.008	.054	.007	.004	.0011
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2
UNNAMED LAKE MOE07															
48.18 86.06		82/6/3	12	.05	.31	.002	.07	<.003	<.002	.08	.031	.110	.005	.004	.0008
		82/7/13	12	.06	.31	.002	.07								
		82/10/5	8	.02	.31	.002	.02	.006	<.002	.07	.028	.081	.011	<.001	.0011
MEANS				.04	.31	.002	.05	.005	.002	.08	.030	.096	.008	.003	.0010
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2
UNNAMED LAKE MOE08															
48.28 86.02		81/9/9	6	<.01	.21	.001	<.01								
UNNAMED LAKE MOE09															
48.24 86.06		81/9/9	7	<.01	.17	<.001	<.01								
		82/6/2	12	.01	.20	.001	.02	<.003	<.002	.04	.021	.084	.003	.002	.0010
		82/7/13	12	.02	.20	.001	.03								
		82/7/14	12	.02	.16	.001	.03								
		82/10/5	12	<.01	.21	<.001	<.01	<.003	.002	.02	.013	.029	.003	.003	.0006
MEANS				.01	.19	.001	.02	.003	.002	.03	.017	.057	.003	.003	.0008
SIZE:				5	5	5	5	2	2	2	2	2	2	2	2
UNNAMED LAKE MOE10															
48.14 86.07		81/9/9	12	<.01	.21	.001	<.01								
		82/6/3	12	<.01	.27	.002	.06	<.003	<.002	.06	.012	.072	.002	.004	.0006
		82/7/13	12	.02	.25	<.001	.04								
		82/10/5	12	<.01	.27	.001	<.01	<.003	.002	.05	.023	.088	.002	.005	<.0005
MEANS				.01	.25	.001	.03	.003	.002	.06	.018	.080	.002	.005	.0006
SIZE:				4	4	4	4	2	2	2	2	2	2	2	2
UNNAMED LAKE MOE11															
48.06 85.57		81/9/9	3	.01	.32	.002	<.01								

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE * <		PARAMETERS ----->											
		DATE yr/mo/dy	DEPTH M	NH4 mg/l	TKN mg/l	NO2 mg/l	NO3 mg/l	Pb mg/l	Ni mg/l	Al mg/l	Mn mg/l	Fe mg/l	Cu mg/l	Zn mg/l	Cd mg/l
UNNAMED LAKE MOE12															
48.11	85.44	82/6/3	7	<.01	.26	.002	.09	<.003	<.004	.06	.018	.060	<.001	.003	<.0005
		82/7/13	12	.02	.24	.002	.10	<.003	<.002	.09	.036	.140	.001	.004	<.0050
		82/10/5	10	<.01	.28	.002	.09	<.003	<.002	.09	.036	.140	.001	.004	<.0050
MEANS				.01	.26	.002	.09	.003	.003	.08	.027	.100	.001	.004	.0028
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2
UNNAMED LAKE MOE16															
48.22	85.54	81/9/9	12	.04	.27	.002	.02								
		82/6/2	12	.03	.31	.003	.06	<.003	<.002	.33	.031	.210	.001	.008	<.0005
		82/7/13	12	.04	.37	.002	.07	<.003	<.002	.38	.029	.160	.005	.008	<.0005
		82/10/5	12	.06	.37	.002	.03	<.003	.011	.42	.028	.270	.003	.015	.0005
MEANS				.04	.33	.002	.05	.003	.005	.38	.029	.213	.003	.010	.0005
SIZE:				4	4	4	4	3	3	3	3	3	3	3	3
UNNAMED LAKE MOE17															
48.13	85.48	82/6/3	10	<.01	.24	.001	.10	<.003	.002	.12	.019	.108	.001	.006	.0005
		82/7/13	12	.03	.21	.002	.10								
		82/10/5	7	.01	.26	.001	.03	<.003	<.002	.11	.011	.029	.001	.006	<.0005
MEANS				.02	.24	.001	.08	.003	.002	.12	.015	.069	.001	.006	.0005
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2
UNNAMED LAKE 6A22															
48.22	86.09	81/9/9	12	.01	.17	.001	.02								
		82/6/2	12	<.01	.25	.002	.05	<.003	<.002	.06	.011	.070	.005	.004	<.0007
		82/6/3	12	<.01	.22	.002	.05	<.003	<.002	.05	.010	.330	.002	.004	<.0005
		82/7/14	12	.04	.21	.002	.06								
		82/10/5	12	<.01	.26	.001	.03	<.003	.005	.07	.014	.047	.003	.004	<.0005
MEANS				.02	.22	.002	.04	.003	.003	.06	.012	.149	.003	.004	.0006
SIZE:				5	5	5	5	3	3	3	3	3	3	3	3
UNNAMED LAKE 6A24															
48.22	86.09	81/9/9	2	.03	.36	.001	<.01								
		82/6/2	3	<.01	.28	.002	.04	<.003	<.002	.11	.021	.080	.004	.005	.0005
		82/7/13	4	.02	.30	.001	.02								
		82/10/5	2	.03	.32	.001	.01	<.003	<.002	.09	.011	.057	.001	<.001	<.0005
MEANS				.02	.32	.001	.02	.003	.002	.10	.016	.069	.003	.003	.0005
SIZE:				4	4	4	4	2	2	2	2	2	2	2	2

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE yr/mo/dy	DEPTH M	NH4 mg/l	TKN mg/l	NO2 mg/l	NO3 mg/l	Pb mg/l	Ni mg/l	Al mg/l	Mn mg/l	Fe mg/l	Cu mg/l	Zn mg/l	Cd mg/l
UNNAMED LAKE 6A25															
48.22	86.09	81/8/12	0	.02	.23	.001	<.01								
		81/9/9	12	.02	.23	.001	.02								
		82/6/3	10	.03	.25	.002	.05	<.003	.003	.07	.024	.100	<.001	.004	.0006
		82/7/14	12	.06	.26	.001	.05								
		82/10/5	10	.01	.26	.001	<.01	<.003	<.002	.09	.021	.086	<.001	.002	<.0005
MEANS				.03	.25	.001	.03	.003	.003	.08	.023	.093	.001	.003	.0006
SIZE:				5	5	5	5	2	2	2	2	2	2	2	2
UNNAMED LAKE 6A27															
48.22	86.08	81/9/9	12	.01	.17	<.001	<.01								
		82/6/2	12	<.01	.18	.001	.04	<.003	<.002	.04	.029	.046	.003	.003	<.0005
		82/7/13	12	.02	.16	.001	.04								
		82/10/5	12	<.01	.17	<.001	<.01	.004	<.002	.03	.008	.015	.001	.001	<.0005
MEANS				.01	.17	.001	.03	.004	.002	.04	.019	.031	.002	.002	.0005
SIZE:				4	4	4	4	2	2	2	2	2	2	2	2
UNNAMED LAKE 6D14															
48.26	85.47	81/9/9	10	<.01	.27	<.001	<.01								
		82/6/2	2	<.01	.22	<.001	<.01	<.003	<.002	.06	.009	.077	.001	.006	<.0009
		82/10/5	12	.05	.43	.002	.09	<.003	.040	.11	.009	.067	.001	.014	<.0005
MEANS				.02	.31	.001	.04	.003	.021	.09	.009	.072	.001	.010	.0007
SIZE:				3	3	3	3	2	2	2	2	2	2	2	2
WILLOW LAKE															
48.28	86.01	81/8/12	0	<.01	.22	.001	.00								
CASCADE RIVER															
48.08	86.03	82/8/10	0	<.01	.22	.003	.05								
		82/10/5	0	<.01	.34	.003	.05	<.003	<.002	.29	.011	.140	.001	.005	<.0005
MEANS				.01	.28	.003	.05	.003	.002	.29	.011	.140	.001	.005	.0005
SIZE:				2	2	2	2	1	1	1	1	1	1	1	1

THUNDER BAY

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LATT.	WATER BODY LONG.	* SAMPLE *		PARAMETERS											
		DATE	DEPTH	NH4	TKN	NO2	NO3	Pb	Ni	Al	Mn	Fe	Cu	Zn	Cd
		yr/mo/dy	M	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
NICHOLS COVE CREEK															
48.23	86.11	82/8/10	0	.02	.27	.003	.06								
		82/10/5	0	<.01	.27	.003	<.01	<.003	<.002	.31	.016	.220	.001	.002	<.0005
		MEANS		.02	.27	.003	.04	.003	.002	.31	.016	.220	.001	.002	.0005
		SIZE:		2	2	2	2	1	1	1	1	1	1	1	1
NORTH SWALLOW RIVER															
48.13	86.06	82/8/10	0	<.01	.28	.003	.05								
		82/10/5	0	<.01	.32	.003	.02	<.003	.003	.36	.025	.140	.002	.008	<.0005
		MEANS		.01	.30	.003	.04	.003	.003	.36	.025	.140	.002	.008	.0005
		SIZE:		2	2	2	2	1	1	1	1	1	1	1	1
SWALLOW RIVER															
48.10	86.05	82/8/10	0	.01	.26	.003	.05								
		82/10/5	0	<.01	.30	.002	.04	<.003	<.002	.34	.015	.140	.001	.008	<.0005
		MEANS		.01	.28	.003	.05	.003	.002	.34	.015	.140	.001	.008	.0005
		SIZE:		2	2	2	2	1	1	1	1	1	1	1	1
WHITE GRAVEL RIVER															
48.18	86.09	82/8/10	0	<.01	.20	.003	.15								
		82/10/5	0	<.01	.36	.003	.05	<.003	<.002	.34	.012	.120	.005	.004	<.0005
		MEANS		.01	.28	.003	.10	.003	.002	.34	.012	.120	.005	.004	.0005
		SIZE:		2	2	2	2	1	1	1	1	1	1	1	1

